Tropical Legumes II Project

TROPICAL LEGUMES II

1972-2012 ICRISAT

Four Seasons of Learning and Engaging Smallholder Farmers

Progress of Phase 1

Edited by

Tsedeke Abate

CIAT 45
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture
A Remarkable Record of Science for Change
Since 1967

IITA
Research to Nourish Africa

Citation: Abate T. (ed.). 2012. *Four Seasons of Learning and Engaging Smallholder Farmers: Progress of Phase 1*. PO Box 39063, Nairobi, Kenya. International Crops Research Institute for the Semi-Arid Tropics. 258 pp.

ISBN: 978-92-9066-546-5
Order Code: BOE 057

Images

Cover: Women farmers' group, Bougoula, Mali (24/10/2011)
Back: Young woman farmer, Bheemanakunte village, Tumkur District, Karnataka, India (02/09/2011)

Four Seasons of Learning and Engaging Smallholder Farmers

Progress of Phase 1

Edited by
Tsedeke Abate

March 2012

Abbreviations and Acronyms

ABI	Agri-Business Incubator (ICRISAT)
ADD	Agricultural Development Division (Malawi)
ADP	Agricultural Development Program (Malawi)
AGRA	Alliance for a Green Revolution in Africa
ALS	Angular Leaf Spot
ANGRAU	Acharya NG Ranga Agricultural University (Andhra Pradesh)
Anth	Anthracnose
AOPP	Association des Organisations Paysannes des Producteurs
AP	Andhra Pradesh
APSSCA	Andhra Pradesh State Seed Certifying Agency
APSSDC	Andhra Pradesh State Seed Development Corporation
AR4D	Agricultural Research for Development
ASA	Agricultural Seed Agency (Tanzania)
Asco	Ascochyta
ASSMAG	Association of Small-Scale Seed Multipliers Action Group (Malawi)
BCMV	Bean Common Mosaic Virus
BILFA	Bean Improvement for Low Soil Fertility in Africa
CBB	Common Bacterial Blight
CVRC	Crop Variety Release Committee
CVRC	Central Variety Release Committee (India)
DAP	Diamonium-Phosphate (fertilizer)
DUS	Distinctness, Uniformity and Stability
ECABREN	East and Central Africa Bean Research Network
EUCORD	European Cooperative for Rural Development
FAO	Food and Agricultural Organization (of the United Nations)
FLS	Floury Leaf Spot
FTC	Farmer Training Center
G x E	Gene-Environment Interaction
GGP	Groundnut Germplasm Project
GRD	Groundnut Rosette Disease
GSP	Groundnut Seed Project
HH	Hosehold(s)
IARCs	International Agricultral Research Centers
ICSN	International Chickpea Screening Nursery
IPM	Integrated Pest Management
ISTA	International Seed Trade Association
KEPHIS	Kenya Plant Health Inspection Service
KOF	Karnataka Oilseeds Federation
Ksh	Kenyan Shilling
KSSC	Karnataka State Seed Corporation
KVK	Krishi Vigyan Kendra
LGA	Length of Growing Period
LZARDI	Lakes Zone Agricultural Research and Development Institute
M+E	Monitoring and Evaluation
MOA	Ministry of Agriculture
MSc	Master of Science (degree)
MSSCL	Maharashtra State Seed Corporation Ltd

NARES	National Agricultural Research and Extension System
NASFAM	National Association of Smallholder Farmers in Malawi
NASSPA	National Smallholders Seed Production Association (Malawi)
NPT	National Performance Trial
NSC	National Seed Corporation
NSO	National Seeds Organization
NSS	National Seed Service
OQS	Other Quality Seed
PABRA	Pan-Africa Bearn Research Network
PDKV	Dr. Punjabro Deshmukh Krishi Vidyalaya
PICS	Purdue Improved Cowpea Storage
PREA	Participatory Research and Extension Approach
QDS	Quality Declared Seed
QTL	Quantitative Trait Loci
RCBD	Randomize Complete Block Design
RRS	Regional Research Station (India)
SCI	Seed Certifying Institute
SFCI	State Farms Corporation of India
SMD	Sterility Mosaic Disease
SNNPR	Southern Nations, Nationalities and Peoples Region (Ethiopia)
SSD	Single Seed Descent
SNP	Single Nucleotide Polymorphism
TLS	Truthfully Labeled Seed
UPAs	Unites de Production Agricole
WACCI	West Africa Center for Crop Improvement (University of Legun, Accra, Ghana)
WASA	West Africa Seed Alliance
WECABREN	West and Central Africa Bean Research Network

Four Seasons of Learning and Engaging Smallholder Farmers: An Outline of Progress

Tsedeke Abate
Tropical Legumes II Project
ICRISAT-Nairobi

Summary

The Tropical Legumes II (TL II) project, funded by the Bill & Melinda Gates Foundation, aims to improve the lives and livelihoods of smallholder farmers in the drought-prone areas of Sub-Saharan Africa (SSA) and South Asia (SA) through improved productivity and production of six major tropical legumes – chickpea, common bean, cowpea, groundnut, pigeonpea and soybean. TL II is jointly implemented by ICRISAT, CIAT and NARS. The project was implemented in 10 target countries that included Western and Central Africa, Eastern and Southern Africa and India, during Phase 1 (Sept 2007 – Aug 2011). Progress made during this period was reviewed in 2011 at regional meetings held in ICRISAT-Patancheru, India (May 9-11 and Sept 5-6); Ibadan, Nigeria (16-18 May); and Lilongwe, Malawi (22-25 May). This paper presents highlights of progress made in the project during its first phase.

Conditions for tropical legumes production are highly variable among regions, countries, and even within a country in terms of socio-demographics, ownership of asset, information sources, technology adoption, and investment in AR4D. Many of the target countries are faced with small, fragmented landholdings; aging research and farming population; low level of literacy; and mostly low level of investment.

The participatory variety selection (PVS) approach has helped to speed up the release process of improved varieties. A total of 80 varieties of the six grain legumes have been released across target countries and nearly 93,000 MT of various classes of seed have been produced and used by smallholder farmers. The project has also supported 37 graduate students to pursue studies toward their advanced degrees (26 MSc and 11 PhD). Nearly 240,000 farmers have been exposed to new technologies through field days, demonstrations, seed fairs, and agricultural shows, among others.

Introduction

The Tropical Legumes II (TL II) project, funded by the Bill & Melinda Gates Foundation, aims to improve the lives and livelihoods of smallholder farmers in the drought-prone areas of Sub-Saharan Africa (SSA) and South Asia (SA) through improved productivity and production of six major tropical legumes – chickpea (*Cicer arietinum*), common bean (*Phaseolus vulgaris*), cowpea (*Vigna unguiculata*), groundnut (*Arachis hypogaea*), pigeonpea (*Cajanus cajan*) and soybean (*Glycine max*). It is anticipated that productivity would increase by 20% and improved varieties would occupy 30% of all tropical legumes mentioned here by the end of the project year. TL II is planned for three phases totaling 10 years. The first phase lasted from September 2007 to August 2011.

TL II is jointly implemented by ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), CIAT (Spanish acronym for: International Center for Tropical Agriculture), IITA (International Institute of Tropical Agriculture), and Ntional Agricultural Research Systems (NARS). The project has formed a wide range of partnerships with advanced research institutions, NGOs, and several other projects funded by the BMGF and other organizations, in order to create synergy and speed up the development process for smallholder farmers.

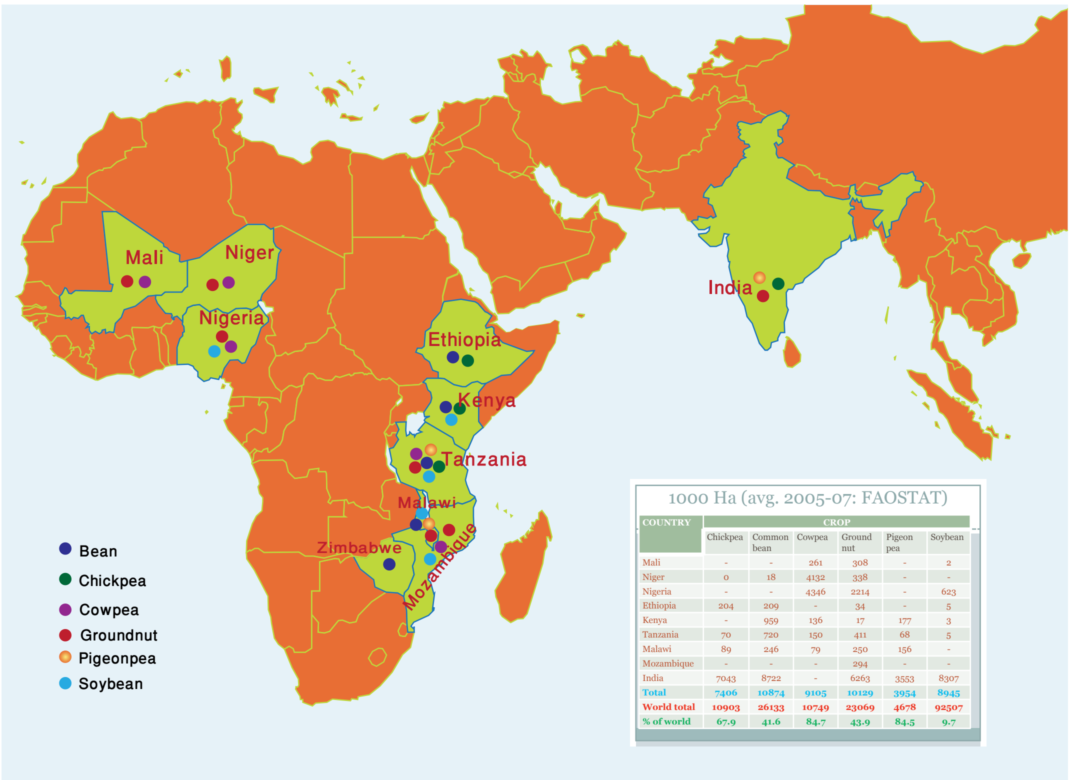
TL II was implemented in 10 target countries during Phase 1. These were Mali, Niger, and Nigeria representing West and Central Africa (WCA); Ethiopia, Kenya, Malawi, Mozambique, Tanzania and Zimbabwe in Eastern and Southern Africa (ESA); and India, representing South Asia (Figure 1-1).

The TL II project's approach for improving the productivity and production of tropical legumes includes, among others:

- Understanding the legumes' environment (through baseline, market and impact studies, effective monitoring and evaluation systems) and leveraging existing knowledge;
- Developing farmer- and market-preferred crop varieties and integrated crop management technologies;
- Establishing sustainable seed production and delivery systems;
- Capacity building for NARS; and
- Creating awareness and reaching farmers with available technologies.

Detailed presentations of progress made and lessons learned during Phase 1 are presented for each of the two crosscutting (targeting and seed systems) and six crop objectives in the respective sections that follow this report. Highlights of progress made so far are presented here.

Figure 1-1: TL II target countries in Phase 1



1000 Ha (avg. 2005-07: FAOSTAT)

COUNTRY	CROP					
	Chickpea	Common bean	Cowpea	Ground nut	Pigeon pea	Soybean
Mali	-	-	261	308	-	2
Niger	0	18	4132	338	-	-
Nigeria	-	-	4346	2214	-	623
Ethiopia	204	209	-	34	-	5
Kenya	-	959	136	17	177	3
Tanzania	70	720	150	411	68	5
Malawi	89	246	79	250	156	-
Mozambique	-	-	-	294	-	-
India	7043	8722	-	6263	3553	8307
Total	7406	10874	9105	10129	3954	8945
World total	10903	26133	10749	23069	4678	92507
% of world	67.9	41.6	84.7	43.9	84.5	9.7

The Environment

Data on understanding the grain legumes' environment in the target countries have been obtained from baseline studies through household surveys (e.g. Asfaw et al 2009; Kiresur et al 2009a, 2009b; Lokesha et al 2009a, 2009b; Simtowe et al 2009; and Suhasini et al 2009a, 2009b); Ndjeunga et al 2010; situation analyses studies (Kassie et al 2009; Katungi et al 2009); literature reviews of published works (Shiferaw et al 2008a; Abate et al 2011, 2012; Kassie et al 2011).

Table 1-1 presents highlights of some data on socio-demographic information, ownership of some physical capital, sources of information on improved technologies, adoption, and investment by target

Table 1-1: Examples of selected baseline data in TL II countries

Parameter	Country								
	Mali	Niger	Nigeria	Ethiopia	Kenya	Malawi	Mozambique	Tanzania	India
Socio-demographic information									
Age (yrs)	57.20	46.90	47.80	43.30	48.70	45.00	-[1]	45.40	46.70
Education (# yrs)	1.60	0.50	3.10	2.80	7.30	5.00	-	4.80	6.50
HH size (number)	18.90	10.30	9.30	7.00	6.30	4.80	-	5.20	6.20
Farm size (ha/household)	7.90	11.90	7.80	2.60	1.70	1.10	3.60	2.70	2.50
TL II legumes plot size (ha/ household)	1.31	1.75	0.68	0.48	0.14	0.27	0.43	0.27	1.03
TL II crops as percent of total area (%)	12.92	33.50	16.02	9.61	27.98	28.13	12.26	18.62	19.41
Ownership of physical capital (%)									
Radio	85.00	70.80	76.10	79.40	87.20	53.00	-	-	22.60
Television	23.00	16.30	28.80	1.90	19.20	3.00	-	-	55.70
Mobile phone	52.30	0.50	43.60	12.20	44.00	5.00	-	-	-
Information sources on agricultural technologies (%)									
Government extension	-	13.23	27.50	41.95	2.00	28.70	70.50	73.83	24.31
Another farmer	-	19.77	60.00	53.61	85.00	52.53	41.60	22.62	84.12
Research	-	21.50	-	4.15	0.00	-	-	15.70	3.07
NGOs	-	4.30	-	0.97	2.00	3.10	-	-	0.33
Adoption and constraints to adoption (%)									
Use of improved seed	3.00	5.00	6.00	42.53	37.40	21.83	20.92	19.00	-
Farmers using own saved seed	80.47	86.42	70.87	66.00	31.40	73.67	-	72.50	80.00
Unavailability of seed (as constraint)	83.44	60.00	55.56	-	-	60.00	-	71.60	37.49
Access to credit	46.00	43.00	9.00	73.51	73.00	-	-	14.40	17.66
Investment in AR4D									
Total spending (million US$ PPP 2005)	24.60	6.20	239.60	68.60	171.50	-	17.70	77.20	1400.00
Spending per farmer (US$ PPP 2005)	9.66	1.53	32.88	2.24	13.36	-	2.12	4.76	25.02[2]
Intensity ratio (%)[3]	0.64	0.25	0.42	0.27	1.30	-	0.38	0.50	0.38

1 Data not given/not available; 2 Author's estimation; 3 Spending as a percentage of agricultural output (AgDP)

country governments in agricultural research for development. The table reveals high variability among regions and countries on the various parameters measured – i.e. issues are region-specific or country-specific. Other studies show that variability exists even within countries.

Here are the major conclusions from the baseline and situation analysis studies:

- Rural smallholder households are dominated by aging populations (avg. 48 years) and low levels of education (< 4 years of schooling);
- Research systems in the SSA region are also faced with aging population, with the average age of researchers more than 50 years;
- Grain legumes account for less than 20% of total cultivated area in the majority of target countries (exceptions are: Niger, Malawi, and Kenya);
- Use of improved, modern varieties was generally low across target countries during the baseline studies; unavailability of improved seed and, in some cases, lack of access to credit have been identified as major bottlenecks for improved variety adoption;
- More than 70% of farmers use their own saved seed across target countries; the only exception is Kenya, where own saved seed accounted for just over 34%;
- Depending on the country, farmer-to-farmer exchange and government extension are two major sources of information on agricultural technologies for farmers;
- The radio would be the most appropriate means of disseminating information on agricultural technologies in Africa whereas television would be appropriate for India;
- The current investment in AR4D falls short of the recommended 1.0-1.5% intensity ratio (i.e. investment as percentage of AgDP).

Fast-Tracking and Variety Release

Screening for desirable traits (grain yield, tolerance to biotic and abiotic factors) has progressed according to the set milestones, or better. Large numbers of lines have been provided to NARS programs. NARS scientists also made crosses and carried out their screening process according to their needs and priorities.

Each of the crop objectives has carried out a large number of PVS trials in the target countries using released varieties or pre-released advanced lines, in comparison with one or more local check(s), over the three to four seasons between 2007/08 and 2010/11. A total of 80 varieties have been released during this period (Table 1-2). The countries (and number of varieties released) were Mali (4), Niger (8), Nigeria (7), Ethiopia (8), Kenya (13), Malawi (3), Mozambique (18), Tanzania (9), and India (10). In terms of crops these were chickpea (12), common bean (6), cowpea (14), groundnut (22), pigeonpea (9), and soybean (17).

All of these are farmer- and market-preferred varieties that have been identified through the PVS trials in respective countries. Their yield advantages over the checks ranged from 5% to 300%. The range (and average) for each of the crops were: 5-54% (30%) for chickpea; 110-115% (113%) for common bean, 56-300% (124%) for cowpea; 27-78% (47%) for groundnut; 27-59% (38%) for pigeonpea; and 5-38% (17%) for soybean, as presented in Table 1-2. Some of the varieties with the same pedigree have been released in more than one country. These included chickpea varieties ICCV 00305, ICCV 00108, and ICCV 97105 released both in Kenya and Tanzania; the cowpea variety IT97k-499-35 released in Mali, Niger and Nigeria; and the soybean variety TGx 1740-2F released in Kenya and Malawi (Table 1-2).

Table 1-2: Tropical legume varieties released under TL II during its first phase (Sept 2007 – Feb 2011)

Variety code (local name)	Year	Country	On-farm yield (Kg per Ha)	Yield advantage over check (%)
Chickpea				
ICV 03107 (Minjar)[δ]	2010	Ethiopia	1700	43
ACOS Dube [λ]	2011	Ethiopia	1800	Superior seed
BGD 103[δ]	2008	India	1800	13
MNK-1 λ	2010	India	1600	15
ICCV 00108[δ]	2009	Kenya	2030	18
ICCV 00305[λ]	2009	Kenya	1800	5
ICCV97105[δ]	2010	Kenya	2400	40
ICCV95423λ	2010	Kenya	2250	31
ICCV 92318 (Mwanza)[λ]	2011	Tanzania	1192	19
ICCV 00108 (Mwanza 1)[δ]	2011	Tanzania	1432	43
ICCV 00305 (Mwanza 2)[λ]	2011	Tanzania	1536	54
ICCV 97105 (Ukiriguru 1)[δ]	2011	Tanzania	1456	46
Common bean				
SUG-131 (Deme)	2008	Ethiopia	2200	116
A19 x OMNAZCr-02-11 (Batu)	2008	Ethiopia	2070	110
SNNRP-120 (Hawassa Deme)	2008	Ethiopia	2500	NA
GLP-2	2011	Ethiopia	2770	116
ECAB-0056	2011	Ethiopia	2617	110
CAW-02-04-11-4-1 (SARI-1)	2011	Ethiopia	2500	NA
Cowpea				
CZ1-94-23-1 (Gana Shoba)	2009	Mali	1500	65
CZ11-94-5C (Cinzana Tilimani)	2009	Mali	1000	60
IT97K-499-35 (Jiguiya)	2010	Mali	1000	70
IT93K-876-330 (Fakson)	2010	Mali	1500	80
IT97K-499-35 (IT)	2009	Niger	800	300
IT97K-499-36 (IT)	2009	Niger	700	200
IT98K-205-8 (IT)	2009	Niger	800	300
IT98K-573-11 (IT)	2010	Niger	500	100
IT97K-499-35 (SAMPEA-10)	2008	Nigeria	835	60
IT89KD-288 (SAMPEA-11)	2009	Nigeria	800	56
IT89KD-391 (SAMPEA-12)	2009	Nigeria	900	71
IT82E-16 (IT-16)	2011	Mozambique	650	100
IT00K-1263 (IT-1263)	2011	Mozambique	800	150
IT97K-1069-6 (IT-1069)	2011	Mozambique	800	150
Groundnut				
R-2001-3[Ψ]	2008	India	3819	77
Dh 4-3[Ψ]	2008	India	2125	59
ICGV 91114[Ψ]	2009	India	1500	46
Chintamani 2[Ψ]	2009	India	1661	27
ICGV 87846[β]	2010	India	1536	55
R-2001-2[Ψ]	2010	India	1842	56

Table 1-2: continued

Variety code (local name)	Year	Country	On-farm yield (Kg per Ha)	Yield advantage over check (%)
ICGV 0035$^{0\Psi}$	2010	India	1827	55
ICG 9346	2010	Niger	956	52
RRB	2010	Niger	720	36
Fleur 11	2010	Niger	694	33
J11	2010	Niger	1453	68
ICGV-SM- 01711 (Nachningwea 09)$^{\beta}$	2009	Tanzania	1800	88
ICGV-SM-01721 (Masasi 09)$^{\beta}$	2009	Tanzania	1500	56
ICGV-SM-83708 (Mnanje 09)$^{\beta}$	2009	Tanzania	1600	78
ICGV-SM-99555 (Managaka 09)$^{\Psi}$	2009	Tanzania	1400	55
ICGV-SM-99557 (Naliendele 09)$^{\Psi}$	2009	Tanzania	1400	55
ICGV-SM 01513	2011	Mozambique	1450	61
ICGV-SM 01514	2011	Mozambique	1520	69
ICGV-SM 99541	2011	Mozambique	1530	70
ICGV-SM 99568	2011	Mozambique	1380	53
CG 7	2011	Mozambique	1400	56
JL 24	2011	Mozambique	1370	52
Pigeonpea				
ICPH 2671 (Pushkal)$^{\chi}$	2008	India	2500	27
ICEAP 00850	2009	Kenya	1457	12
ICEAP 00936	2009	Kenya	1380	10
ICEAP 00557 (Mwaiwathu Alimi)	2009	Malawi	1192	28
ICEAP 01514/15	2011	Malawi	1430	59
ICEAP 00020	2011	Mozambique	1630	30
ICEAP 00040	2011	Mozambique	1680	34
ICEAP 00554	2011	Mozambique	1870	50
ICEAP 00557	2011	Mozambique	1960	56
Soybean				
EAI 3600	2009	Kenya	1276	NA
Gazelle	2009	Kenya	1149	NA
Nyala	2009	Kenya	1119	NA
Black Hawk	2009	Kenya	1004	NA
Hill	2009	Kenya	989	NA
TGx 1740-2F (DPSB8)	2010	Kenya	1000	7
TGx 1895-33F (Tikolore)	2010	Kenya	1500	8
TGx 1740-2F	2011	Malawi	2248	38
TGx 1835-10E*	2008	Nigeria	834	25
TGx 1904-6F	2009	Nigeria	3034	24
TGx 1987-10F*	2010	Nigeria	1626	9
TGx 1987-62F (DPSB19)*	2010	Nigeria	1567	5
TGx 1937-1F (Olima)	2011	Mozambique	2585	29
TGx 1485-1D (Sana)	2011	Mozambique	2619	30
TGx 1908-8F (Wima)	2011	Mozambique	2670	33
TGx 1904-6F (Zamboane)	2011	Mozambique	2733	36
TGx 1740-2F (Wàmini)	2011	Mozambique	2838	41

$^{\delta}$ desi type; $^{\lambda}$ kabuli type; $^{\Psi}$ Spanish type; $^{\beta}$ Virginia bunch; * resistant to rust; NA= not available

Seed Production and Delivery Systems

The seed production and delivery system team has identified more than two dozen types of seed production models across target countries. Eight, eight and 10 seed production systems have been reported for Breeder/Foundation Seed, Certified Seed, and Other Quality Seed production systems in the target countries (Table 1-4).

Systems varied from country to country (Figure 1-2). NARS research centers are responsible for Breeder and Foundation Seed production across target countries, with the exception of Tanzania, where public sector with contact farmers is responsible for production of these classes of seed. IARCs produce Foundation Seed (FS) directly in six of the nine target countries; public sector with contract farmers produces Foundation Seed in four of the nine countries. Individual farmers and farm groups, agricultural universities, IARCs with contract farmers, and small private seed companies also produce FS in one or more countries of the TL II target countries.

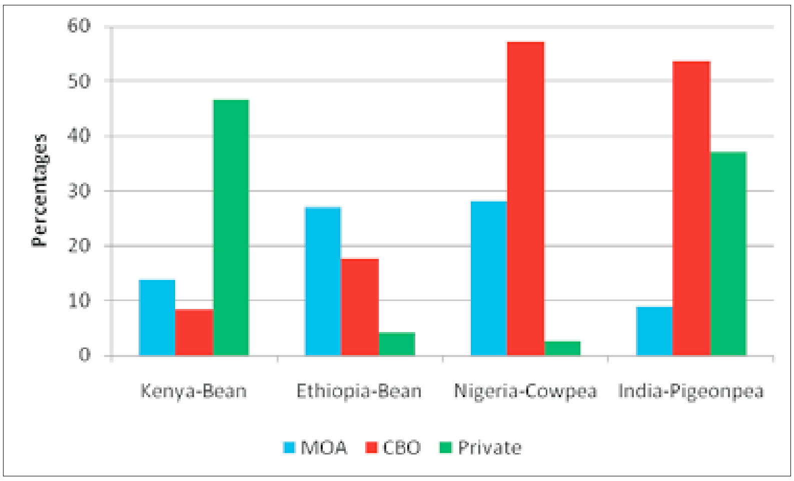


Figure 1-2: Importance of seed production systems in selected countries

Certified Seed (CS) is largely produced by the private sector and farmers groups, depending on the country (Table 1-4). Small-scale farmers, the public sector with contract farmers and public sector seed firms are also known to be part of the CS production system. Agricultural universities produce CS only in Nigeria.

Individual seed producers are engaged in Other Quality Seed (OQS) production in seven of the nine countries (Table 1-4). Farmers' groups/unions/cooperatives and community-based seed system farmer groups operating by themselves produce OQS in five and four of the nine countries, respectively. NGOs facilitate the production of OQS in Ethiopia and Kenya. Schools, NGOs directly, the PDKV model, farmers involved in payback system, seed village, and government supported non-certified seed production models are also practiced in one country each.

It has been observed that there is no much enthusiasm by large seed companies to engage in grain legume seed production because of low margin of profit, as farmers could recycle their own saved seed for up to five years. Much attention is therefore paid to strengthening community-based and farmer level seed production systems.

A total of 16 seed delivery models have been identified in the nine target countries. These too varied from country to country. Kenya (7), Ethiopia (6), and Tanzania (5) have the largest number of models; Malawi (4), India (3), Niger (3), Nigeria (3), Mali (2), and Mozambique (2) have fewer numbers, as shown in Table 1-4.

Table 1-3: Seed production and delivery models tested in TL II target countries (as at Sept 2009)

Model	Country								
	Mali	Niger	Nigeria	Ethiopia	Kenya	Malawi	Moz	Tanzania	India
production									
NARS (at research center)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Public sector with contract farmers (who have “good record”)	No	No	No	No	Yes	Yes	No	Yes	Yes
Public sector at FS farm	No	No	No	No	No	No	No	Yes	No
Individual farmers & farm groups producing FS	Yes	Yes	Yes	No	No	No	No	No	No
Agricultural universities	No	No	Yes	No	No	No	No	No	Yes
IARCs producing FS directly	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No
IARCs contracting farmers	No	No	No	No	No	Yes	No	No	No
Small private seed companies in FS	Yes	No	No	No	No	No	No	No	No
Certified Seed production									
Private sector (company)	No	Yes	Yes	No	Yes	No	No	Yes	Yes
Private sector (company), w/ cont. farm	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
From private sector with contract farmers	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Public sector - seed firms	No	No	Yes	No	No	No	No	Yes	No
Public sector with contract farmers	No	No	Yes	Yes	No	No	No	Yes	Yes
Farmer groups	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
Small-scale seed producers	Yes	Yes	Yes	No	No	Yes	Yes	No	No
Agricultural universities	No	No	Yes	No	No	No	No	No	No
Other Quality Seed production									
Individual seed producers (independent)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No
CBSS farmer groups operating by themselves	Yes	No	No	Yes	Yes	No	No	Yes	No
Schools	No	No	No	No	No	No	No	Yes	No
NGOs directly	No	No	No	No	No	No	No	No	Yes
NGOs facilitated	No	No	No	Yes	Yes	No	No	Yes	No
Farmers’ groups/unions/coops	Yes	No	No	Yes	Yes	Yes	Yes	No	No
PDKV model	No	No	No	No	No	No	No	No	Yes
Farmers involved in payback system	No	No	No	No	Yes	No	No	No	No
Seed village	No	No	No	No	No	No	No	No	Yes
Government supported, non-certified	No	No	No	No	Yes	No	No	No	No

Table 1-3: continued

Model	Country								
	Mali	Niger	Nigeria	Ethiopia	Kenya	Malawi	Moz	Tanzania	India
Delivery Models									
Agro-input dealers selling directly to clients	Yes	Yes	Yes	No	Yes	No	No	No	No
Private companies - direct to client groups	No	Yes	Yes	No	Yes	No	No	Yes	Yes
Farmers sell to traders (via local markets)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Farmer to farmer exchange (trade)	NA	NA	NA	NA	NA	NA	NA	No	NA
Farmer growers to grain exporters	No	No	No	Yes	No	Yes	No	No	No
Via larger farmers associations/unions/coops	No	No	No	Yes	No	Yes	No	No	No
CBSS	NA	NA	NA	NA	NA	NA	NA	No	NA
NGOs give seed loan	No	No	No	Yes	Yes	No	Yes	No	No
Farmer Field Schools	No	No	No	No	No	Yes	No	Yes	No
Schools	No	No	No	No	No	No	No	Yes	No
Soybean resource centers	No	No	No	No	Yes	No	No	Yes	No
Seed revolving fund	No	No	No	No	Yes	Yes	No	No	No
Seed banks	No	No	No	Yes	No	No	No	No	No
Seed revolved from payback system	No	No	No	No	Yes	No	No	No	No
Seed village	No	No	No	No	No	No	No	No	Yes
Parastatals directly involved in delivery	No	No	No	Yes	No	No	No	No	No
Awareness raising (reaching farmers)									
Small pack seed samples	No	Yes	No	Yes	Yes	No	No	No	No
Field days	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FFS/FRG	No	No	No	Yes	No	Yes	No	Yes	No
Demonstrations	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Posters/manuals	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Flyers	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Seed fairs	No	Yes	No	Yes	Yes	No	Yes	Yes	Yes
Agricultural shows	No	No	No	Yes	Yes	No	Yes	Yes	No
Displays at research centers	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Newspapers	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Open market promotion/town meetings	No	No	No	Yes	Yes	No	No	No	No
Radio	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Television	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Video clips	No	No	Yes	Yes	Yes	No	No	Yes	No
Website	No	No	No	No	No	No	No	No	No

Source: Adapted from Louise Sperling (presentation at the meeting in Bamako, September 2009)

As stated earlier in this chapter, availability and access to seed are crucial factors in the adoption of improved technologies by farmers. TL II invested significant amounts of time and efforts on this aspect during Phase 1 and will continue to further strengthen it. Nearly 93,000 MT of various classes of seed were produced during Phase 1 across countries (Table 1-4). CS and FS accounted for about 83% and 16% of the total seed production, respectively. Country wise, India and Ethiopia accounted for about 80% and 12% of the total seed produced.

Considering each crop (and seeding rate in kg per ha) for common bean (100), groundnut (90), chickpea (70), soybean (60), cowpea (20), and pigeonpea (8.5), this amount of seed would be sufficient to plant a minimum of 1.3 million ha. Considering an average of 0.25 ha of the legumes per household, this would mean more than 5.2 million households.

Capacity building

Good progress has been made in terms of both physical and human capacity building in the NARS of target countries. Laboratory and office equipment has been purchased and submitted to the NARS; irrigation facilities for conducting research on drought tolerance have been installed or upgraded in all countries. Seed storage facilities have been renovated and are in use in the countries which needed these.

A total of 37 students have registered for their MSc (26) and PhD (11) degrees in national, regional and overseas universities (Table 1-5). Six of the total students are women. Many of these have either completed their studies and joined back the national programs or are in the process of completing.

Awareness raising

Awareness creation has been effected through field days, demonstrations, seed fairs, agricultural shows, dealing with farmers' research groups/farmer field schools, and distribution of small pack seed samples. TL II has been able to reach nearly 240,000 farmers during its first phase (Table 1-6). Kenya, India and Ethiopia had particular successes with reaching farmers.

Table 1-4: Various classes of seed produced (MT) in target countries under TLII (Sept 2007 – Aug 2011).

Country	Seed Class				Total
	Breeder	Foundation	Certified	Others[1]	
Country totals					
India	276	5,345	68,853	143	74,617
Ethiopia	22	7,813	3,351	178	11,365
Malawi	47	158	3,188	0	3,393
Kenya	16	953	13	314	1,296
Nigeria	0	59	513	68	640
Tanzania	22	194	263	82	561
Mozambique	0	53	495	0	548
Mali	8	54	145	44	251
Niger	1	47	172	0	220
Total	**392**	**14,676**	**76,993**	**829**	**92,890**
Crop totals					
Chickpea	188	3,279	52,289	0	55,756
Groundnut	99	2,562	23,066	241	25,968
Common bean[2]	0	8,537	0	492	9,030
Soybean	7	87	776	0	871
Pigeonpea	98	109	395	96	698
Cowpea	0	101	467	0	568
Total	**392**	**14,676**	**76,993**	**829**	**92,890**

1 Includes quality declared seed and seed from small packs

2 Estimates based on multiplication ratio of the crop and percentage of harvest sold as seed each year

Table 1-5: Graduate degree students supported by the TL II project

Name	Gender	Country	University	Area of thesis/dissertation
		MSc Candidates		
Siaka Dembele*	M	Mali	Ibadan	Cowpea breeding
Abdoulaye Diarra	M	Mali	Ouagadougou	Ag economics
Mamary Traore	M	Mali	Mali	Groundnut breeding
Nana M.I. Garba	F	Niger	Niamey	Groundnut breeding
Abdou Souleymane*	M	Niger	Ibadan	Cowpea breeding
Habibu Aliyu	M	Nigeria	Ahmadu Bello	Cowpea breeding
Shaahu Aondover	M	Nigeria	Makurdi	Soybean breeding
Auwal Adamu Umar	M	Nigeria	Ahmadu Bello	Cowpea breeding
Mitiku Demissie	M	Ethiopia	Haramaya	Chickpea marketing
Mekbib Gebretsadik	M	Ethiopia	Norway	Chickpea adoption
Tadesse Sefera	M	Ethiopia	Haramaya	Chickpea breeding
Peter Kaloki	M	Kenya	Nairobi	Drought, chickpea
Waweru Felix Muchiri	M	Kenya	Nairobi	Common bean breeding
Nancy W. Njogu	F	Kenya	Egerton	*Helicoverpa* in chickpea
Scolastica Wambwa	F	Kenya	Kenyatta	Seed systems
Wilson Chafutsa	M	Malawi	Malawi	Groundnt seed technology
Guilhermino Boina	M	Mozambique	Malawi	Cowpea seed storage
Henrique Victor Colial	M	Mozambique	Malawi	Cowpea breeding
John Bulassi Kaunda	M	Mozambique	Malawi	Cowpea breeding
Anica S.F. Massas	F	Mozambique	Malawi	Soybean breeding
Mohamed Ismael	M	Tanzania	Sokoine	Groundnut breeding
Didasi R. Kimaro	M	Tanzania	Sokoine	Cowpea breeding
Juma Mfaume	M	Tanzania	Sokoine	Groundnut breeding
Julius Missanga	M	Tanzania	Sokoine	Cowpea breeding
Justine Alfred Mushi	M	Tanzania	Sokoine	Soybean processing
Viskas Navhale	M	India	Dr. PDKV Akola	Pigeonpea breeding
		PhD Candidates		
Ibrahima Z. Doumbia	M	Mali	Mali	Cowpea breeding
Kayode Ogunsola**	M	Nigeria	Ibadan	Cowpea breeding
Teshale Assefa***	M	Ethiopia	Padova	Common bean breeding
Berhanu Amsalu	M	Ethiopia	Pretoria	Common bean breeding
David Nyongesa	M	Kenya	Dar es Salaam	Agro-enterprise
Lizzie Kachulu	F	Malawi	Zambia	Common bean breeding
Maryama Mayomba	F	Tanzania	Sokoine	Pigeonpea path/breeding
Godwill Makunde	M	Zimbabwe	Free State	Common bean breeding
Tosh Garg	M	India	Punjab	Chickpea breeding
Rachit K. Saxena	M	India	Ousmania	Pigeonpea breeding
S. L. Swargaonkar	M	India	Marathwarda	Pigeonpea breeding

*Joint financing with AGRA (university costs) and TL II (research); **joint financing with Government of Nigeria (university costs) and TL II (research costs); ***TL II covered costs for field operations in Ethiopia

Table 1-6: Total number of farmers reached by TL II during Phase 1

Country	Crop						Total
	Common bean	Groundnut	Chickpea	Pigeonpea	Cowpea	Soybean	
Kenya	67,906	-[3]	2,350	-	-	3,483	73,739
India	-	30,801	12,095	13,415	-	-	56,311
Ethiopia	22,690	-	8,746	-	-	-	31,436
Nigeria	-	5,505	-	-	11,973	4,013	21,491
Tanzania	-	6,000	1,844	5,689	987	3,559	18,079
Mozambique	-	4,000	-	-	3,889	6,374	14,263
Mali	-	7,817	-	-	640	-	8,457
Niger	-	6,419	-	-	1,062	-	7,481
Malawi	-	-	-	4,155	349	-	4,504
Total	90,596	60,542	25,035	23,259	18,900	17,429	235,761

3 Not applicable – crop not included in the country

References

Abate T, Shiferaw B, Gebeyehu S, Amsalu B, Negash K, Assefa K, Eshete M, Aliye S, Hagmann J. 2011. A systems and partnership approach to agricultural research and development – lessons from Ethiopia. Outlook on Agriculture 40(3):213-220.

Abate T, Alene AD, Bergvinson D, Shiferaw B, Silim S, Orr A and Asfaw S. 2012. Tropical Grain Legumes in Africa and South Asia: Knowledge and Opportunities. ICRISAT, 112 pp.

Asfaw S, Shiferaw B. 2009. Baseline assessment of groundnut, chickpea and pigeonpea for Eastern and Southern Africa. ICRISAT, 32 pp. www.icrisat.org/tropicallegumesII

Beintema N. 2010. Financial and human capacities in agricultural R&D in developing countries: recent evidence. Presentation at the parallel session on capacity development, GCARD-2010, Montpellier 18-31 March 2010. www.asti.cgiar.org/pdf/global_revision.pdf.

Kassie M, Shiferaw B, Asfaw S; Abate T, Muricho G, Teklewold H, Eshete M, Assefa K. 2009. Current situation and future outlooks of the chickpea sub-sector in Ethiopia. ICRISAT Working Paper, ICRISAT and EIAR, 39 pp. www.icrisat.org/tropicallegumesII

Kassie M, Shiferaw B, Muricho G. 2011. Agricultural technology, crop income and poverty alleviation in Uganda. World Development 39(10): 1784-1795.

Katungi E, Farrow A, Chianu J, Sperling L, Beebe S. 2009. Common bean in Eastern and Southern Africa: a situation and outlook analysis. International Center for Tropical Agriculture [CIAT], 56 pp.

Kiresur VR, Bantilan MCS, Parthasarathy RP, Rao GDN, Padmaja R, Anupama, KV, Suhasini K, Kulkarni G. 2009a. Chickpea breeding and seed delivery efforts to enhancing the impact on the livelihoods of the poor in drought-prone areas of South Asia – insights from baseline studies. Summary report. ICRISAT, 118 pp. www.icrisat.org/tropicallegumesII

Kiresur VR, Kulkarni GN, Kulkarni VS. 2009b. Baseline assessment of chickpea for Karnataka state in India. ICRISAT, 113 pp. www.icrisat.org/tropicallegumesII

Lokesha H, Parthasarathy RP, Bantilan MCS. 2009a. Baseline assessment of groundnut in Karnataka state in India. Baseline research report for Tropical Legumes-II. ICRISAT. www.icrisat.org/tropicallegumesII

Lokesha H, Parthasarathy RP, Nageswara Rao GD; Bantilan MCS. 2009b. Baseline assessment and market survey analysis of the groundnut in Raichur district of Karnataka. ICRISAT. www.icrisat.org/tropicallegumesII

McIntyre BD et al (eds.). 2009. Agricultural Knowledge, Science and Technology: Investment and Economic Returns. In Agriculture at a Crossroads, International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) Global Report, World Bank, Washington, DC, pp. 495-550.

Ndjeunga J, Ibro A, Cisse Y, Ben Ahmed, Miko I, Moutari A, Abdoulaye A, Kodio O, Mohammed SG, Echekwu CA. 2010. Characterizing village economies in major groundnut producing countries in West Africa: cases of Mali, Niger and Nigeria. ICRISAT, 89 pp. *www.icrisat.org/tropicallegumesII*

Shiferaw BA, Kebede TA, You, L. 2008a. Technology adoption under seed access constraints and the economic impacts of improved pigeonpea varieties in Tanzania. Agricultural Economics 3: 1-15.

Shiferaw B, Okello J, Muricho G, Omiti J, Silim S, Jones R. 2008b. Unlocking the Potential of High-Value Legumes in the Semi-Arid Regions: Analyses of the Pigeonpea Value Chains in Kenya. Research Report No. 1. International Crops Research Institute for the Semi-Arid Tropics. 56 pp.

Simtowe F, Shiferaw B, Asfaw S, Abate T, Monyo E, Siambi M Muricho G. 2009. Socio-economic assessment of baseline pigeonpea and groundnut production conditions, farmer technology choice, market linkages, institutions and poverty in rural Malawi. ICRISAT, 127 pp. *www.icrisat.org/tropicallegumesII*

Suhasini P, Kiresur VR, Rao, GDN, Bantilan MCS. 2009a. Adoption of chickpea varieties in Andhra Pradesh: pattern, trends and constraints. ICRISAT, 67 pp. *www.icrisat.org/tropicallegumesII*

Suhasini, P, Kiresur VR, Rao GDN, Bantilan MCS. 2009b. Baseline assessment of chickpea for Andhra Pradesh state in India. Baseline research report for Tropical Legumes-II. ICRISAT, 150 pp. *www.icrisat.org/tropicallegumesII*

Thirtle C, Lin L, Piesse J. 2003. The impact of research-led agricultural productivity growth on poverty reduction in Africa, Asia and Latin America. World Development 31(12):1959-1975.

Enhancing Groundnut Productivity and Production in India

P Vindhiya Varman (TNAU-Coimbatore), KP Viswanatha (UAS–Bangalore), HL Nadaf (UAS-Dharwad), CR Konda (UAS-Raichur), SN Nigam (ICRISAT-Patancheru), P Janila (ICRISAT-Patancheru)

Breeding

Summary

This report highlights the progress made during the last three years of project implementation in India, where it is implemented in two states, Tamil Nadu and Karnataka. Cultivation of obsolete varieties and non-availability of quality seed are identified as major constraints for groundnut productivity in these states. The major activities under this project are focused on farmers' participatory variety selection (PVS), crop improvement, and capacity building. Significant achievements have been made in all the areas.

PVS trials were conducted in three districts of Tamil Nadu and five districts of Karnataka. A total of 635 PVS and 1,222 paired comparison trials were conducted during the project period. From the results of these trials in the two states, nine improved varieties were identified; the PVS method enabled adoption and spread of new varieties in the target districts. Further spread of these varieties is fuelled by creating awareness among the farmers through 87 field days conducted in the last three years, in which 5,456 farmers participated and visited the demonstration plots in farmers' fields. Awareness is also created through publications; one booklet and seven pamphlets/leaflets on various aspects of groundnut in local languages were published and distributed to farmers. The nucleus and breeder seed production programs at state universities were supported to enable increased seed production and also entry of improved varieties into seed chain with concomitant phasing out of obsolete varieties. During the project period a total of 159.09 MT of nucleus and breeder seed were produced by formal seed sector in both the states.

The breeding activities at partner centers are strengthened, first through supply of about 270 new breeding lines by ICRISAT to the NARS during the three year period. Evaluation trials of these new lines were conducted at partner locations and superior lines were identified based on their performance. Second, through infrastructure strengthening; hybridization facilities were strengthened at one partner center in Karnataka, ARS, Chintamani and appropriate phenotyping facilities were established at three research centers, viz., Coimbatore and Tindivanam in Tamil Nadu and Raichur in Karnataka for efficient screening of breeding material for foliar diseases and drought. Significant progress has been made at partner centers in breeding activities. Over 200 fresh crosses were completed during the same period by partner centers with various objectives such as improving foliar disease resistance, yield, and oil quality; segregating generations (F_2–F_7) derived from 259 cross combinations were studied and selections made during the same period.

Under capacity building, two students (one MSc and one PhD) have successfully completed their research and submitted their thesis under this project. Two scientists and six technicians were also trained at ICRISAT. Over 5000 farmers were made aware of improved varieties by directly reaching them either through VPS and comparison trials (1,602 farmers) or through farmers visit to the trial plots on field days (5,456 farmers). More than 10000 farmers have received farmer-friendly literature in local languages with information on new PVS and groundnut production aspects.

Project background

Groundnut is one of the largest oilseed crops in India. In 2007/08, it was grown in 6.29 million hectares with a total production of 9.18 million MT and it contributed 36% to the total oilseed production in the country. It is cultivated primarily in the semi-arid tropical regions of the country under rainfed conditions during the main rainy season (Jun/Jul – Oct/Nov); 80.2% of groundnut area is rainfed and the remaining 19.8% of area is irrigated mainly in the post-rainy season. It has large concentrations in the states of Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu. Being a rain-fed crop, its yield is largely determined by the quantum and temporal distribution of rainfall.

Although India is the second largest producer of groundnuts after China, the average groundnut yields, 1,459 kg per ha, in the country are far below the yields realized in many other countries such as USA, China, Argentina, Indonesia and Vietnam. These low yields are due to a number of biotic and abiotic constraints, including farmers' lack of access to quality seed and other inputs and improved technologies and information, and frequent droughts and attacks by insect pests and diseases. There exists an enormous potential to improve the groundnut yields in the country through adoption of varietal technology by the farmers and quality seed supply.

Project sites

Tamil Nadu

Groundnut constitutes 81% of the area and 91% of the production of total area under oilseeds in this state. It is grown in an area of 413,000 ha with production of 896,000 MT. The productivity of 2169 kg per ha is good even though it is predominantly grown as rainfed crop (62%) in the state. The groundnut area in the state was highest during 1992-93 with 1.188 million ha and it gradually declined to about 500,000 to 600,000 ha during the last 10 years. The reason for the decline in area is mainly due to the switch over to other more profitable crops like maize. The import of much cheaper oil like palm oil and the consequent price fluctuation is also another important reason for the decline in area. However, there is a potential to increase the area to 900,000 ha.

Popular varieties cultivated in Tamil Nadu

The varieties cultivated before the inception of project TL II include TMV 7, an old variety released in 1967 and preferred among the farmers for its taste. The other varieties include, VRI 2 and VRI 3, both are two decade old varieties, Co Gn 4 is released in 2001, and TMV Gn 13 released in 2006. Although TMV Gn 13 is the most recent release it is poor yielder.

Strategies for improving groundnut production and productivity in Tamil Nadu

1. Quality seeds of improved varieties to be made available in time;
2. Promoting mechanised cultivation due to acute labour scarcity, for which suitable machinery needs to be introduced for cultivation and harvesting;
3. Adoption of integrated nutrient management practices, optimum use of NPK and micronutrients needs to be addressed; and
4. Adoption of integrated pest management practices.

Karnataka

The groundnut area in Karnataka has declined significantly from 1.18 million ha in 1998 to around 0.8 m ha in 2008. The productivity in the state is very low at 652 kg per ha compared to the national average of about 1459 kg ha per ha in 2008. It is interesting to note that the productivity levels in the state hover around 600-700 kg per ha since the 1970's, which is cause of serious concern in this state warranting immediate interventions to increase the productivity of the crop to arrest further decline in groundnut area. In this state, about 42% of groundnut area is rainfed and contributes to 21% of production.

Popular varieties cultivated in Karnataka

Before the project initiation, the predominant variety was TMV-2; an obsolete variety released in 1940 and occupied 85% of groundnut area in the state. The productivity of TMV 2 was very low and hence farmers were not happy to grow groundnut as it is less remunerative and also there was no systematic supply of groundnut seed. In addition to TMV 2, the other varieties under cultivation included another old variety, JL 24 (released in 1985) and GPBD 4 (released in 2002), but are confined to a very limited area.

Strategies for improving groundnut production and productivity in Karnataka

1. Introduction of new varieties in the farmers' fields with concomitant large-scale replacement of the old variety, TMV-2;
2. Intensive training of farmers regarding improved cultivation aspects of groundnut; and
3. Adoption of integrated crop management to increase productivity, as the soils are poor with respect to their nutrient status.

Achievements

Participatory varietal selection

Farmer-preferred varieties of groundnut were identified through farmers' participatory varietal (PVS) trials. In PVS, the farmers in target districts of the two states were given a basket of 8 – 10 chosen improved varieties along with the check and they were allowed to select based on their performance and preferences. The varieties thus identified are given for paired comparisons along with locally preferred check to demonstrate the improvements gained through use of the farmer-preferred variety over local variety. Field days were conducted at the site of paired comparisons to create awareness among the farmers in the partner and nearby villages about the improved varieties selected through PVS. This resulted in adoption and fast spread of the new farmer-preferred varieties of groundnut in and around partner villages. Subsequently, the varieties were entered in state/national level multi-location testing for formal release.

Tamil Nadu

PVS trials were conducted in Namakkal, Erode and Thiruvannamalai districts of Tamil Nadu, where nine villages in each district were selected. Keeping in view the local requirements, seven Virginia bunch types were chosen for Namakkal district and eight Spanish bunch types for Erode and Thiruvannamalai districts. A total of 296 PVS trails were conducted in 2008 and together in 2009 and 2010 a total of 742 paired comparisons of identified variety along with local check were conducted in 38 villages across three districts. In Namakkal ICGV 87846 emerged as a preferred variety and recorded a 36-87% pod yield increase over the local check (Table 2-1). ICGV 00351 and TVG 004 were farmer-preferred varieties in Erode and Thiruvannamalai (Tables 2-2 and 2-3).

Table 2-1: Performance of ICGV 87846 in on-farm trails in Namakkal district of Tamil Nadu

Season	Name of the trials	No. of trials	Pod yield (kg per ha)		
			ICGV 87846	Local	% Increase over local
2008 rainy	PVS trials	90	1630	869	87.6
2009 rainy	Paired comparisons	237	1019	646	57.7
2010 rainy	Paired comparisons	198	1985	1457	36.2
Total / Mean		**525**	**1536**	**991**	**54.9**

Table 2-2: Performance of ICGV 00351 in on-farm trials in Erode district, Tamil Nadu

Season	Name of the trials	No. of trials	Pod yield (kg per ha)		% Increase over TMV Gn 13
			ICGV 00351	TMV Gn13	
2009 rainy	PVS trials	107	1185	868	36.5
2010 rainy	Paired comparisons	103	2227	1717	29.7
Total / Mean		210	1706	1293	31.9

Table 2-3: Performance of ICGV 00351 and TVG 004 in on-farm trials in Thiruvannamalai district, Tamil Nadu, India

Season	Name of the trials	No. of trials	Pod yield (kg per ha)			% Increase over TMV Gn 13	
			ICGV 00351	TVG 004	TMV Gn13	ICGV 00351	TVG 004
2008 rainy	PVS trials	99	1429	1270	996	43.5	27.5
2009 rainy	PVS trials	81	1580	1417	1293	22.2	9.6
2010 rainy	comparisons	90	1890	2235	1888	-	18.4
Total / Mean		**270**	**1633**	**1641**	**1392**	**17.3**	**17.9**

Karnataka

PVS trials were conducted in Chitradurga, Tumkur, Chikballpur, Bagalkot and Raipur districts of Karnataka. In the districts of Chitradurga, Tumkur, Chikballpur, 10 varieties were chosen and 117 mother and baby trials were conducted in 2008 in eight villages (Table 2-4). Of these, five varieties were advanced for the following season PVS to conduct 144 trials in 12 villages (Table 2-5). ICGV 91114 was identified as the farmer-preferred variety and paired comparisons were conducted in 33 villages in 2010 (Table 2-6).

Table 2-4: Performance of varieties in PVS trials conducted in Chitradurga, Tumkur, Chikballpur districts of Karnataka in 2008 rainy season.

Varieties	Average pod yield (kg per ha)									
	Gulya	GulyaGollarahatti	Yalagondanahalli	Kaparahalli	HuliKunte	Jadekunte	Nerlahalli	Hirehalli	Konasagar	Average
Chintamani-1	1186	1088	1078	902	706	882	1186	1098	220	946
Chintamani-2	2097	1774	1823	1431	1333	1431	1735	1548	310	1527
R-2001-2	1950	1638	1989	1441	1313	1480	2174	1470	294	1532
R-2001-3	1715	1646	1715	1333	1382	1313	1754	1274	255	1409
GPBD-4	1088	1294	1186	931	921	892	1156	1009	205	987
K-6	1029	1107	951	941	960	1196	1186	1019	202	984
ICGV-00350	1480	1303	1264	951	843	1156	1264	1226	250	1109
ICGV-04096	1989	2078	1901	1362	1088	1392	1744	1519	304	1522
ICGV-91114	1196	1392	1323	1107	872	1098	1362	960	192	1073
TMV(Gn)-13	1137	1166	1196	882	804	911	1019	1039	208	945
TMV-2	1284	1039	1382	1039	941	1196	1401	1000	200	1076
									SEM ±	0.68
									CD at 5%	1.142
									CV %	12.6

Table 2-5: Performance of varieties in PVS trials conducted during 2009 rainy season in Chitradurga, Tumkur, and Chikballpur districts of Karnataka (two mother trials and 10 Baby trials were conducted conducted at each village, total 144 trials).

Varieties	Average pod yield (kg per ha)													Oil content average (%)
	Marur	Jangamarahalli	Hosahalli	Hareyabbi	G.Gollarahatti	Gulya	Hire halli	Chikkahalli	Rudrammanahalli	KondlaHalli	Nerlahalli	Marammanahalli	Average	
Chintamani-2	1593	1650	1421	1568	1593	1535	1600	1658	1650	1633	1544	1674	1593	53.7
R-2001-2	1699	1691	1503	1666	1698	1405	1633	1764	1682	1600	1650	1789	1648	49.7
ICGV – 00350	1356	1184	1282	1282	1209	1300	1323	1453	1307	1430	1200	1560	1324	53.9
ICGV – 04096	1747	1664	1764	1690	1756	1886	1796	1895	1764	1870	1634	2017	1790	54.4
ICGV- 91114	1397	1502	1363	1372	1552	1487	1511	1642	1470	1502	1445	1641	1490	48.2
TMV-2	1103	1119	988	1118	1242	1102	1274	1323	1200	1201	1176	1315	1180	51.3
													SEM $\pm$1.13	
													CD 2.62	
													CV 17.90	

In eight villages of Bagalkot district, 34 mother and baby trials were conducted in 2008 with a set of eight chosen varieties (Table 2-7). In 2009, a set of 20 mother and baby trials were conducted in six villages from the identified five varieties (Table 2-8). In 2010, a total of 192 paired comparisons with the identified variety ICGV 00350 and locally preferred variety TMV 2 were conducted (Table 2-9).

In Raichur district, 54 mother and baby trials were conducted with nine chosen varieties in 2008, from which six were selected for the next season testing and in 2009 (Table 2-10). Based on these two entries, ICGV 00350 and R-2001-2 were identified for paired comparisons in 2010. A total of 255 paired comparisons were conducted in 17 villages (Table 2-11).

Multi-location testing: Nine varieties were identified through PVS from the two states. These varieties were multiplied and entered into multi-location testing at state and national levels. This testing is a prerequisite for official release of the varieties. They are now in different states of release and pre-release at state and national levels as indicated in Table 2-12.

Awareness about varieties*:* In both the states where the project is implemented, over 5,000 farmers were made aware of improved varieties by directly reaching them either through PVS and comparison trials (1,857 farmers) or through farmers' visits to these trial plots on field days. A total of 87 field days on farmers' fields were conducted in which 5,456 farmers have participated.

In Tamil Nadu, over 6,000 farmers were made aware of improved groundnut varieties. One thousand thirty eight farmers were made aware as participant of PVS and paired comparisons and another 871 farmers were made aware of improved varieties through 18 field days conducted in farmers' fields. In addition, 5,531 farmers were reached through state and regional farmers' fairs (Table 2-13).

In five districts of Karnataka over 5,000 farmers were directly reached and made aware of improved varieties; 819 farmers were reached through participation in the PVS and paired comparisons and another 4,585 farmers from the nearby villages visited the farmers plots where improved varieties were cultivated during 69 field days conducted over three years.

Table 2-6: Performance of ICGV 91114 in large-scale yield testing trials conducted during 2010 rainy season in Chitradurga, Tumkur, and Chikballpur districts of Karnataka

No.	Village name	Yield (kg per ha) (average yield of 10 trails/village)		% yield increase over check
		ICGV-91114	TMV-2 (check)	
1	Gulya	850	680	20
2	GulyaGollarahtati	820	656	19
3	Hariyabbe	910	728	21
4	T-Gollahalli	950	760	22
5	Hariyabbepalya	830	664	19
6	V.K.Gudda	820	656	19
7	Hirehalli	780	624	18
8	Chikkahalli	760	608	18
9	Rudrammanahalli	900	720	21
10	Siddapura	880	704	21
11	Laxmipura	720	562	19
12	Hottappanahalli	810	632	21
13	Kondlahalli	770	601	20
14	Nerlahalli	830	647	21
15	Marammanahalli	800	624	21
16	Mogalahalli	720	562	19
17	Konasagara	750	585	19
18	B.G.Kere	770	601	20
19	Maruru	830	647	21
20	Hosahalli	850	663	22.
21	Jangamarahalli	900	684	25
22	Arasikere	880	669	25
23	Mangalawada	720	547	20
24	Budusanahalli	960	730	27
25	Dwaranakunte	830	631	23
26	Nejanti	750	570	21
27	Vajarahalli	780	593	22
28	Chinnahalli	940	714	26
29	Battalahalli	910	692	25
30	Karigatammanahalli	860	654	24
31	Mittemari	700	532	20
32	Kanagamakalapalli	760	578	21
33	Burugamadugu	810	616	23
Mean		823	640	21

Table 2-7: Performance of varieties in PVS trials conducted during 2008 rainy season in Bagalkot district of Karnataka

No.	Variety	Mean pod yield (kg per ha)	Traders' Rating		
			Good	Medium	Poor
1	GPBD4	2469	15	0	0
2	DH86	1933	0	1	17
3	R 2001-3	4344	0	18	0
4	DH 101	2114	0	17	1
5	DH 4-3	2196	1	16	0
6	ICGV 91114	1097	18	0	1
7	ICGV 00350	2996	1	0	18
8	R 2001-2	2976	0	1	17
9	TMV2 (check)	919	18	0	0

Table 2-8: Performance of varieties in PVS trials conducted during 2009 rainy season in Bagalkot district of Karnataka

Variety	Mean pod yield (kg per ha)			
	Badami (2 village 10 farmers)	Bagalkot (2 villages 6 farmers)	Bilagi (3 villages 4 farmers)	Mean (7 villages 20 farmers)
GPBD4	1664	2077	1869	1828
R 2001-3	1673	2670	2937	2238
DH 4-3	1059	1543	1469	1282
ICGV 00350	1655	2700	2670	2170
R 2001-2	1413	2225	1958	1752
TMV2 (Check)	899	1643	1380	1205
MEAN	1394	2143	2047	1746
CD @5%	138	292	606	314
CV %	11.0	11.5	19.6	12.0

Table 2-9: Performance of ICGV 00350 during 2010 rainy season in Bagalkot district of Karnataka

Taluk	No. of trials	ICGV 00350	TMV 2	Calculated *t*	% increase
Badami	76	1482 ± 76	1028 ± 67	39.10**	44.20
Bagalkot	102	1482 ± 80	1039 ± 69	42.29**	42.60
Bilagi	14	1478 ± 80	1057 ± 76	14.31**	39.80
Total	192	1482 ± 78	1036 ± 69	59.37**	43.00

Table 2-10: Performance of baby trial varieties in PVS trials conducted during the 2010 rainy season in Raichur district of Karnataka

No.	Entry	Yield (kg per ha)			
		Raichur	Deodurga	Lingasugur	Mean
1	GPBD-4	925	854	833	871
2	R-2001-3	1344	1112	1179	1212
3	Dh-4-3	825	767	804	799
4	ICGV-91114	913	917	979	936
5	ICGV-00350	1456	1163	1425	1348
6	R-2001-2	1367	1183	1250	1267
7	Local check	959	890	964	937
CV (%)					6.2
CD at 5%					116.0

Table 2-11: Results of 255 paired comparisons comprising best performed farmer-preferred varieties conducted during 2010 rainy season in Raichur district, Karnataka

Variety	Yield (kg per ha)			Mean	Remarks
	Raichur	Deodurga	Lingasugur		
ICGV-00350	890	856	888	878	The yield levels were low due to excess rainfall during vegetative and pod development stage
TMV-2 (Local check)	451	446	449	449	
R-2001-2	830	836	865	844	
TMV-2 (Local check)	438	498	458	465	

Table 2-12: Multi-location testing of groundnut varieties in Tamil Nadu

State/variety	Characteristics	Remarks
ICGV 87846	Virginia bunch type; maturing in 125-130 days.	Released as Co6 in 2010
ICGV 00351	Spanish bunch type, drought tolerant	Pre-release
ICGV 91114	Spanish bunch short duration 95-100 days); for rainy and post rainy	Released for Southern Karnataka
Chintamani 2	Spanish bunch; 110 days; resistance to foliar diseases	Released for Southern Karnataka in 2009-10
ICGV-04096	Spanish bunch; 110-115 days duration; foliar disease resistance	Pre-release (now under national evaluation trial)
ICGV 00350	Spanish bunch; Drought tolerant	Pre-release
R-2001-2	High yielding; drought tolerant	Released, and notified in 2010
R 2001-3	Spanish bunch	Released in 2008 for Zones III & IV at national level
Dh 4-3	Spanish bunch	Released in 2008 for the North Eastern Zone for rabi /summer

Table 2-13: Participants in the awareness programs conducted in Tamil Nadu during 2008-10.

State	Awareness programs	Number of conducted	No of participants		
			Men	Women	Total
Tamil Nadu	Field days	18	608	263	871
	State level farmers day	2	2063	741	2804
	Regional agricultural fair	1	2089	638	2727
Total		**21**	**4760**	**1642**	**6402**

Table 2-14: Groundnut seed of various classes produced in Tamil Nadu during 2008-10.

Varieties	Quantity produced in MT			
	2008	2009	2010	Total
Nucleus Seed				
TMV Gn 13	2.25	1.20	1.44	4.89
VRI 2	3.30	2.90	5.35	11.55
CoGn 4	0.55	0.50	1.58	2.63
Total	6.10	4.60	8.37	19.07
Breeder Seed				
TMV Gn 13	4.42	6.82	6.37	17.61
VRI 2	28.34	20.90	23.75	72.99
CoGn 4	1.32	1.20	4.48	7.00
Total	34.08	28.92	34.60	97.60
Foundation Seed				
TMV Gn 13	6.80	7.50	5.45	19.75
VRI 2	33.60	22.50	55.76	111.86
CoGn 4	2.32	3.75	4.61	10.68
Total	42.72	33.75	65.82	142.29
Certified Seed				
TMV Gn 13	13.81	37.50	11.82	63.13
VRI 2	304.53	255.63	658.82	1218.98
CoGn 4	16.24	18.75	5.24	40.23
Total	334.58	311.88	675.88	1322.34

Table 2-15: Truthfully-labeled seed produced (MT) through informal seed systems in Tamilnadu during 2008-10.

Varieties	2008		2009		2010		Total
	Post rainy	Rainy	Post rainy	Rainy	Post rainy	Rainy	
VRI Gn 6	0.38	0.94	0.60	1.20	0.80	1.40	5.32
VRI Gn 7	-	0.60	0.40	0.80	0.70	1.50	4.00
TMV Gn 13	0.50	1.30	1.70	1.90	1.30	2.80	9.50
CoGn 6	-	-	0.80	1.50	1.40	11.70	15.40
ICGV 00351	-	-	-	0.30	0.80	1.40	2.50
TVG 004	0.10	0.30	0.20	0.40	0.30	0.50	1.80
Total	**0.98**	**3.14**	**3.7**	**6.1**	**5.3**	**19.3**	**38.52**

Breeder Seed multiplication

In Tamil Nadu, the Tamil Nadu Agricultural University produced the Nucleus and Breeder seeds of groundnut, while Department of Agriculture produced the Foundation and Certified Seeds. During the three years, 19.07 MT of Nucleus Seed, 97.60 MT of Breeder Seed, 142.29 MT of Foundation Seed and 1,322.34 MT of Certified Seed were produced and distributed (Table 2-14). About 38.5 MT of seed was produced and distributed through informal seed sector (Table 2-15).

In Karnataka, during the project period a total of 42.42 MT of Breeder Seed; 2,297.52 MT of Foundation Seed, and 19869.58 MT of Certified Seed, totaling 22,209.22 MT was produced by formal sector (UAS, Bangalore; UAS, Dharwad, SFCI and Akruthi Associates of India). The nucleus and breeder seed produced by UAS, Dharwad and UAS, Raichur are given in (Tables 2-16 and 2-17). During the same period, 46.52 MT of Certified and Truthfully-labeled seed was produced by informal sector.

Table 2-16: Groundnut seed of various classes produced by Dharwad Center, Karnataka during 2008-10.

Year	Season	Variety	Quantity in tons				
			Nucleus Seed	Breeder Seed	Foundation Seed	Certified Seed	TL Seed
2007-08	Post-rainy	GPBD4	0.95	20.00	-	280.00	
2008	Rainy	GPBD4	4.80	50.00			
2008-09	Post-rainy	GPBD4 DH86	4.5	3.00 50.00	160.00	50.00	
2009	Rainy	GPBD4 DH86	2.00 4.00	172.5 34.5	-	200.00 480.00	80.00* 120.00**
2009-10	Post-Rainy	GPBD4	10.00	80.00	120.00	1000.00**	10.00*
2010	Rainy	GPBD4	0.80	10.00	50.00	1000.00	-
Total			**34.25**	**420.0**	**330.0**	**3010.0**	**210.0**

*=UAS; **=KOF

Table 2-17: Groundnut seed of various classes produced (MT) by Raichur Center, Karnataka in 2009 and 2010.

Year / Season	Class of seed	Variety	Location	Area sown (ha)	Seed quantity produced
2009 rainy season	Basic Seed	R-2001-2	Raichur	0.20	100 kg
Rainy 2010	Nucleus	R-2001-2	Raichur	1.00	200 kg
Rainy 2010	Breeder	R-2001-2	Raichur	4.00	1200 kg
Rainy 2010	Nucleus	ICGV-00350	Raichur	0.50	150 kg
Post Rainy 2010-11	Nucleus	R-2001-2	Raichur	2.00	1200 kg
Post Rainy 2010-11	Nucleus	ICGV-00350	Raichur	0.70	500 kg
Post Rainy 2010-11	Breeder	R-2001-2	Raichur and Kavadimattti	8.00	6000 kg

Varietal screening to drought and foliar diseases

During the project period, ICRISAT has made available a total of 270 new breeding lines to NARS for local evaluation; 22 and 14 sets of eight international trials were sent to UAS, Bangalore, and TNAU, Coimbatore, respectively. Twelve sets of six international trials were sent to UAS, Dharwad. Each trail consisted of 15 new breeding lines. In addition, a high oil content trial with 150 new breeding lines with high/low oil content was sent to TNAU, Coimbatore, and UAS Dharwad. From these trials conducted in Tamil Nadu, the groundnut lines ICGV 02266, ICGV 01124, ICGV 99231, ICGV 01263, ICGV 96155, ICGV 99017, and ICGV 00451 are under evaluation in state and national multi-location testing. Based on their performance in these trials they will be released at state/national level. Another 19 genotypes with high oil content were also identified for further evaluation and multi-location testing.

From the trials conducted by UAS, Bangalore, the genotypes ICGV 00206, ICGV 00211 and ICGV 00189 were identified for foliar disease resistance, and ICGV 05155, ICGV 07240 and ICGV 07225 for drought tolerance, in addition to some other genotypes for confectionery traits and short / medium maturity duration. UAS-Dharwad identified the genotypes, ICGV 05056, ICGV 06142, ICGV 03032, and ICGV 06050 for high oil content and many others for various other traits. UAS-Raichur has identified ICGV 00446, ICGV 00440, ICGV 97079, ICGV 96211, ICGV 96155, ICGV 96172, ICGV 01124, ICGV 95469, ICGV 02266, ICGV 22340, ICGV 00290, ICGV 99210, and ICGV 98372 from international trials supplies by ICRISAT. The identified genotypes will be sent to multi-location testing or if required re-evaluated for another season as well as multiplied for multi-location testing in the next season.

Generation of new breeding lines

At one partner center the facilities for crossing programs to generate new breeding populations were strengthened; this was made possible by erecting hybridization facilities. In the state of Karnataka, such facilities were made at Agricultural Research Station (ARS), Chintamani to expand the breeding activities. In Tamil Nadu, the breeding activities were conducted at research stations located at Tindivanam and Coimbatore. During the project period, 88 fresh crosses were made and segregating populations (F2-F5) derived from 80 crosses were studied and selections were made.

In Karnataka, at ARS-Chintamani, UAS-Bangalore during the project period, 32 fresh crosses were completed and segregating generations (F2-F7) derived from 150 crosses were studied and selections made. At ARS-Bagalkot, UAS, Dharwad 71 fresh crosses were made and six segregating populations (F2-F5) were studied during the project period. At Main Agricultural Research Station (MARS), UAS-Raichur crosses were made involving 17 parents with an objective to develop varieties with foliar disease resistance and segregating populations from 23 cross combinations were studied. The fresh crosses made and breeding material handled are summarized in Table 2-18.

Table 2-18: Summary of breeding material advanced breeding lines in pipeline and varieties released

Partner center in India	TNAU, Coimbatore	UAS-Bangalore	UAS-Dharwad	UAS-Raichur	Total number
Fresh crosses made	88	32	71	189	380
Number of segregating populations (F_2–F_7) studied	80	150	6	23	259
Number of advanced breeding lines in pipeline for release	2 (ICGV 00351; & TVG 004)	2 (ICGV 04096; & ICGV 00350 [released but notification due])	1* (ICGV 00350 [released but notification due])	1 * (ICGV 00350 [released but notification due])	4
Number of varieties released	1 (ICGV 87846)	2 (ICGV 91114; & Chintamani-2 #)	2 (GPBD 4#; & Dh 4-3#)	2 (R 2001-2# & R 2001-2 #)	7
			2* (R 2001-2; R 2001-3)	3* (GPBD 4; ICGV 91114; Dh 4-3))	

* Included by another partner center in the same state; # Lines developed prior to TL II

Capacity building

Ms D Shoba has completed her doctoral studies at TNAU, Coimbatore, and submitted her dissertation titled "Identification of molecular markers for resistance to rust (*Puccinia arachidis*) and late leaf spot (*Phaeoisariopsis personata*) in groundnut (*Arachis hypogaea* L.)". The foliar disease screening facilities developed at Coimbatore under this project were used by the student for phenotyping the parents and mapping populations. Mr Sreenivasa Raghavan from UAS, Raichur completed his MSc research work under the project. Mr. K Girishkumar from TNAU, Coimbatore, Messrs. H V Krishne Gowda, M Manjunatha and Manjunatha Bhanuvally from UAS-Bangalore and Messrs, F C Nadaf and Mirza Sajiulla Baig from UAS-Raichur received hands-on training on groundnut breeding technologies and production aspects and on aspects of virus screening at ICRISAT. Two scientists Drs. M Vaidyalingan and N Manivannan from TNAU, Coimbatore were trained on the use of molecular markers in groundnut breeding at ICRISAT.

Infrastructure facilities

For efficient screening of breeding material for foliar diseases and drought, appropriate phenotyping facilities established at three research centers - Coimbatore and Tindivanam in Tamil Nadu and at Raichur in Karnataka. At TNAU, Coimbatore, the foliar disease screening facility was strengthened by installing a sprinkler system and similarly at TNAU, Tindivanam rain-out shelters were made for screening for drought resistance. Equipment needed to measure drought traits was also provided. At MARS, UAS, Raichur, Karnataka, screening facilities through artificial inoculations for major foliar diseases were created to evaluate the breeding populations for resistance to these diseases.

Publications

A total of eight publications (one booklet and six pamphlets/leaflets) on various aspects of groundnut were published in vernaculars and distributed to farmers. More than 10000 farmers have been received this farmer-friendly literature.

TNAU has published a booklet titled "Improved package of practices for groundnut" in Tamil and distributed to 5960 farmers in three years. Two pamphlets on groundnut varieties, ICGV 87846 and ICGV 00351 (printed in Tamil) were distributed to 6,913 farmers in 2009 and 2010. The pamphlets published in Tamil also include two topics: 'Tips to produce quality seed in groundnut' and 'Techniques to overcome loss of seed viability in *rabi*-summer groundnut'

UAS-Bangalore has published a pamphlet on the farmer-preferred variety ICGV 91114 in Kannada language and made it available to the farmers. UAS-Dharwad has published pamphlets on seed production and processing aspects and groundnut crop production technologies and made it available to farmers on field days. UAS-Raichur has published a leaflet on 'ICM practices in groundnut'.

Seed Production and Delivery Systems

Summary

This report highlights progress made during the last three years of project implementation. Cultivation of obsolete varieties and non-availability of quality seed of improved varieties are identified as major constraints leading to low productivity in groundnut. Low seed multiplication ratio, particularly in groundnut, high volume of the seed, storage insect pests and quick loss of seed variability are the major constraints to efficient seed production and delivery system. The seed scenario in legumes in India is dominated by the informal seed sector.

Breeder Seed is produced by the state agricultural universities. Improved facilities for seed production at NARS centers would result in increased production of Breeder Seed and concomitantly in Foundation Seed. Thus, seed production facilities were strengthened at NARS research stations. In addition, small-scale seed production-processing-storage facilities of about 500 – 1000 MT were facilitated under the project implementation. During the project period a total of 159.09 MT of Nucleus/Breeder seed was produced in both states 19.07 MT of Nucleus Seed, and 97.60 MT of Breeder Seed in Tamil Nadu and 42.42 MT of Breeder Seed in Karnataka. During the same period, Foundation and Certified Seed, 1464.63 MT and 2297.52 MT, respectively, were produced by Tamil Nadu and Karnataka. Tamil Nadu and Karnataka also produced 38.5 MT and 46.52 MT of Truthfully Labeled Seed, respectively, of varieties awaiting formal release and notification.

Two alternate seed system models were developed and promoted in partner states. The first is the PDKV model, in which 2 kg pods of improved varieties was distributed to farmers. They multiply the seed for two seasons to produce 20 kg in the first season, and then 200 kg at the end of the second season. This 200 kg

pod is sufficient to raise crop in 1 ha field in the third season. The cycle is repeated with 2 kg of selected pods from third season. Farmer level self-sufficiency in seed is attained through this model. This system has high adoption among farmers in both states as the majority of them use their own-saved seed. The second seed system model is of semi-formal type, which is being implemented successfully for the past four years in Karnataka state. In this model Basic Seed is supplied to the farmers by the university and farmers can either offer seed production plots for certification to enter formal seed chain or also have an option not to choose for certification. Truthfully labeled seed is produced without certification but it will be monitored by the university/NGOs/farmers' association. A similar model is also promoted in Tamil Nadu. Semi-formal seed systems were found to be very successful in meeting the local groundnut seed demand. In Tamil Nadu, the transport cost of 100 kg of pods alone is about 700 Indian rupees (INR), which is 20% of seed cost (3500 – 4000 INR during last three years). Thus, the alternate seed systems save more than 10% on seed transportation cost.

Through the semi-formal model, implemented in five districts, namely, Erode and Thiruvannamalai in Tamil Nadu and Bagalkot, Hiriyur and Raichur in Karnataka, linkages were established between formal and informal seed sectors through supply of basic quality seed by the university. In Karnataka state, additional linkages were also facilitated through certification of seed production plots by the state seed certifying agencies leading to Certified Seed production. This seed was procured by the state seed corporations or state department of agriculture. The basic seed (100 kg each) of ICGV 87846 was supplied to ABI, ICRISAT, KVK, Sandhiyur and RRS, Vridhachalam for further multiplication and distribution to farmers through this system. Similarly, 100 kg seed of ICGV 00351 was also supplied to ABI, ICRISAT, during the 2010 rainy season.

A workshop with 137 participants involving all stakeholders of seed chain: farmers, private and public seed sectors, NGOs etc. were conducted in Tamil Nadu to appraise the situation of groundnut seed systems. A policy document for the state of Tamil Nadu titled 'Groundnut cultivation and existing seed systems" was prepared and communicated to the authorities. In four training programs conducted in both the states, 493 officials including 72 women from extension department, NGOs and seed sector (both private and public) were imparted training on various aspects of seed production, processing, packing, labeling, storage, and marketing. A total of 4,267 farmers were trained during three years in the two states on various aspects of seed production, seed health and seed processing and storage to encourage local seed production and storage by farmers through PDKV and semi-formal seed systems. Seed production manuals in Tamil and Kannada were published and distributed.

A total of 87 field days on farmers' fields were conducted in eight districts of both states in which 5,456 farmers participated. In addition, two farmers' days and one farmer trade fair were organized at Coimbatore, Tamil Nadu. Over 10000 farmers from the two states were made aware of farmers-preferred varieties of groundnut through various means, as participants in the PVS and paired comparisons, visits to farmer demonstration plots on field days and distribution of pamphlets on farmers' day/fair. Farmers' awareness was also enhanced through print and electronic media, as many as seven television shows, three radio talks and over 15 newspaper publications were made from time to time on aspects of new groundnut varieties and improved production practices. Pamphlets on farmer-preferred groundnut varieties were published - ICGV 87846 and ICGV 00351 in Tamil and ICGV 91114, ICGV 00350 and R 2001-2 in Kannada. More than 5,000 copies of these pamphlets were distributed to the farmers in these states.

During the project period, a total of 6,505 small seed samples ranging from 2 – 10 kg pods were supplied to the farmers. Six farmer-preferred varieties, namely, ICGV 87846, ICGV 00351, ICGV 91114, ICGV 00350, R 2001-2 and GPBD 4 were distributed in these two states. The farmers receiving small seed samples were encouraged to adopt the PDKV model of seed system to multiply the seed of improved varieties and also supply them to the neighboring farmers.

Project sites

Tamil Nadu

The present seed replacement rate in the state is around 3.0%. Local traders are the major suppliers of the seed. Hence, the genetic purity and minimum germination standards are not assured. The cost of seed is usually high due to transportation charges. Furthermore, the supply of seed is restricted to old varieties. In a few districts, farmers save their own seed, but this practice is not common in coastal districts due to high rainfall and high relative humidity, leading to quick loss of seed viability, besides lack of proper storage facilities and financial reason. Participation of private seed companies is practically absent. In Tamil Nadu, the state agricultural university produces the Nucleus and Breeder Seed of groundnut, while Department of Agriculture of the state government produces the Foundation and Certified Seed.

Strategies to improve the quality seed supply in time:

1. Improve the formal seed systems through a vibrant public sector organization/agency: There is a great opportunity to establish a dedicated autonomous state seed corporation in Tamil Nadu or forming an independent seed producing agency as a wing of Department of Agriculture; and
2. Promote informal seed sector to meet the huge demand of the quality seed of groundnut.

Karnataka

The seed replacement ratio in the state during 2007-08 was 9.5 % with a huge gap between demand and supply, which is often met by supply of non-descript seed by traders as TMV 2. Although the seed replacement is slightly better than the situation in the country, TMV 2, an obsolete variety, is still distributed through seed chain due to non-availability of seed of new improved varieties in the seed chain. The Nucleus and Breeder Seed is produced by state agricultural universities, while Certified and Truthfully Labeled Seed is produced and distributed to farmers by state seed corporations, farmers' societies and agricultural universities. The role of private sector is negligible. Although some farmers save their own seed, the seed demand is largely met by supply of seed by traders which, in general, is non-descript.

Strategies to improve the quality seed supply in time:

1. Promote informal seed sector to meet the seed demand and replace obsolete varieties; and
2. Link formal and informal seed sectors for quality seed supply.

The approach

The TL II project for groundnut is implemented in two states in India - Tamil Nadu and Karnataka.The major activities under this project include increased production of Breeder and Foundation Seed to enhance the availability of quality seed of improved varieties in the seed chain, promote alternative seed systems to meet the seed demand, enhanced seed delivery and local seed production and storage capabilities and capacity building. Significant achievements have been made in all the areas.

Project accomplishments

Infrastructure and equipment

The breeder seed production facilities were strengthened at four NARS research stations, one in Tamil Nadu and three in Karnataka.

At TNAU, repairs were made to the existing seed storage godown and threshing floors, and fresh plant threshers and other processing equipment have been purchased.

The existing seed storage unit and threshing-cum-drying yard at ZARS, Hiriyur, UAS-Bangalore, was strengthened and used for various seed production activates. The research station of UAS-Dharwad at Bagalkot district has also been strengthened with infrastructure facilities for Seed production. Fresh plant threshers were purchased and seed storage godown facility is extended. The threshing and drying yards and storage godown were strengthened with cement concrete at ARS-Raichur.

At five centers of NARS, two in Tamil Nadu and three in Karnataka, small-scale seed production-processing-storage facilities of about 500 – 1000 MT are facilitated under the project implementation. Storage godowns are repaired or extended to increase the capacity and quality of storage. Fresh plant threshers have been procured at all the four centers to enable large scale stripping of pods in seed production plots. The drying floors are also strengthened with cement concrete to enable optimum drying of pods which enhances the longevity and viability of seed.

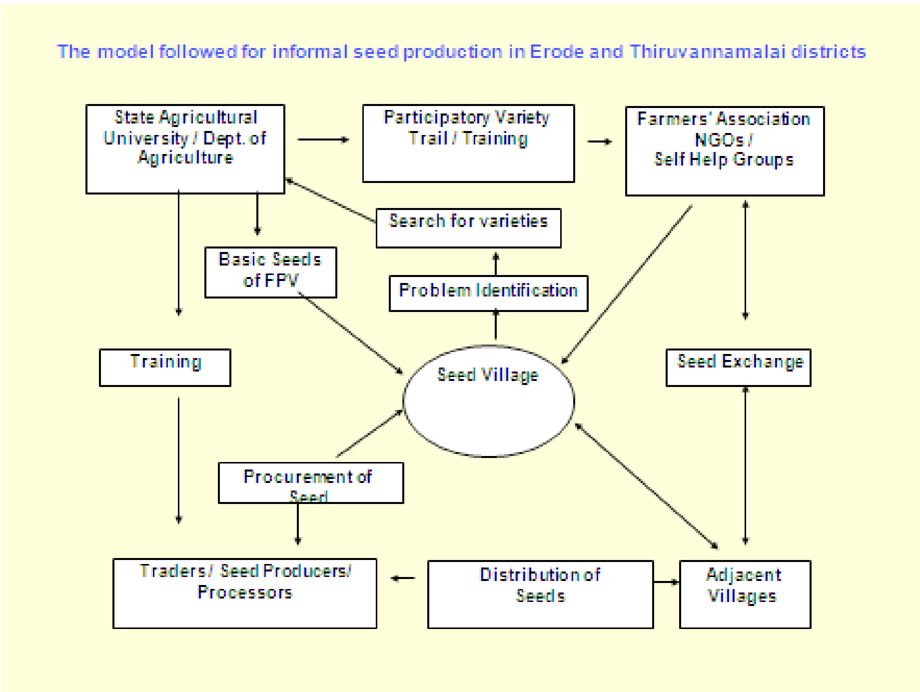
Seed Production of Breeder, Foundation, Certified and Truthfully-Labeled Seed

During the project period a total of 159.09 MT of Nucleus/Breeder seed is produced in both the states; 19.07 MT of Nucleus seed, and 97.60 MT of Breeder seed are produced in Tamil Nadu and 42.42 MT of breeder seed is produced in Karnataka (Tables 2-14, 2-16 and 2-17).

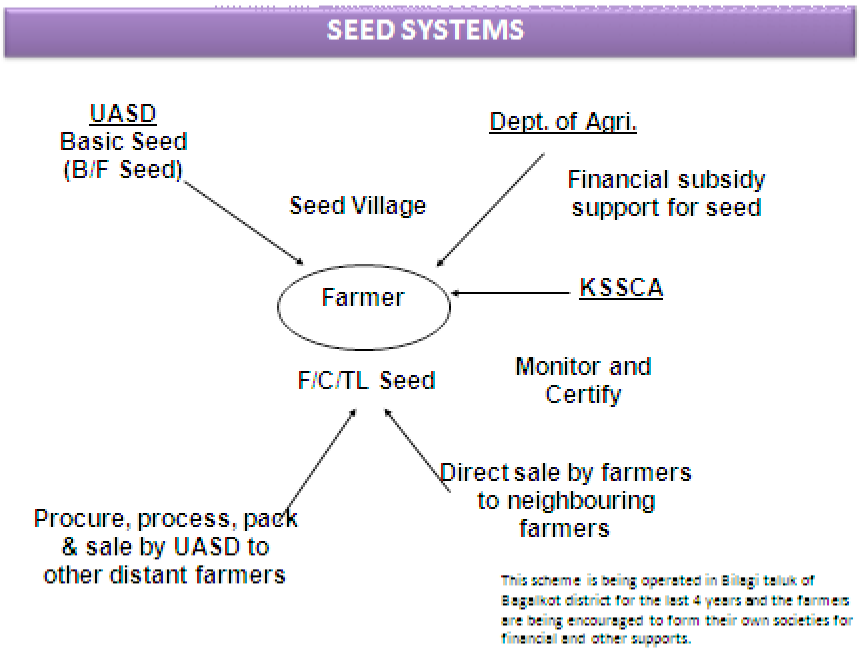
Tamil Nadu

Two seed systems were implemented. In Nammakal district, the PDKV model was promoted. In PDKV model, 2 kg pods of improved varieties were distributed to farmers, who multiply them two seasons to produce 20 kg in first season, and then 200 kg at end of second season. This 200 kg pod is sufficient to raise a crop in 1 ha field in the third season. The cycle is repeated with 2 kg of selected pods from 3rd season. Self-sufficiency in seed is attained by the farmers through PDKV.

A second model of informal system has been adopted in Erode and Thiruvannamalai districts of Tamil Nadu, where seed production is taken up in a village from the basic seed supplied by the University. The seed procurement could then be done by traders or farmers directly. Farmers' associations and non-governmental organizations could be involved in organizing seed production or seed procurement for distribution.



In Karnataka, the PDKV model was promoted. During 2010 rainy season, 10 kg of ICGV-91114 kernel which is sufficient for sowing in 0.25 acre was distributed to 330 farmers each in 33 villages of three major groundnut growing districts of southern Karnataka i.e., Tumkur, Chikballpur, Chitradurga. In Bagalkot district, the UAS-Dharwad partner has promoted a semi-informal seed, which has linkages with the formal seed system. This model has been popular and is implemented successfully for the past four years. In this model basic seed is supplied to the farmers by the university and farmers can offer for certification and enter formal seed chain or without certification but being monitored by university they can produce truthfully labeled seed.



At Raichur also the system similar to that in UAS-Dharwad is under implementation since 2010 rainy season.

Constraints and opportunities for legume seed systems

TNAU has prepared a policy brief on "Groundnut seed plan" for the state of Tamil Nadu and has communicated to policy makers. The salient findings and recommendations are as follows:

- In Tamil Nadu, the present seed replacement rate is around 3%;
- Local traders are the major suppliers of seed;
- Genetic purity and minimum germination standards are not assured;
- The cost of seed is usually high due to transportation charges;
- The supply of seed is restricted to old varieties;
- In order to improve the formal seed system, a vibrant public sector needs to be involved; and
- Organization/agency is necessary. There is a great opportunity to establish a dedicated autonomous state seed corporation or forming an independent seed producing agency as a wing of department of Agriculture Tamil Nadu State Seed Corporation has to be established similar to the corporations in other states of the country.

Formal and informal seed sector linkages

In two districts of Tamil Nadu - Erode and Thiruvannamalai - linkages were established between formal and informal sectors through seed village model where basic quality seed is supplied by the university. Similarly, in two districts of Karnataka - Bagalkot and Raichur - semi-formal seed systems were promoted and found to be a very successful model to meet the groundnut seed demand. Here also, the linkage was facilitated by supply of quality seed to farmers; in addition, farmers can offer the seed production plots to state seed certification agencies and thus produce certified seed which will be lifted by state seed corporations or state department of agriculture for seed subsidy program. Alternatively, the farmers also have the choice of not offering the seed production plots for certification, thus produce truthfully labeled seed, which can be directly supplied to nearby farmers or through university. This model in Karnataka has been very successful.

The basic seed (100 kg each) of ICGV 87846 was supplied to ABI, ICRISAT, KVK, Sandhiyur and RRS, Vridhachalam for further multiplication and distribution to farmers. Similarly 100 kg seed of ICGV 00351 was also supplied to ABI, ICRISAT during the 2010 rainy season.

Transaction costs in seed marketing

Tamil Nadu

In Nammakal district, groundnut crop is grown in only one season so farmers save their own seed as a rule; hence the PDKV model to promote improved varieties has been adopted in this district. In Erode district, traders sell the locally purchased seed and fix the margin at 300-400 INR per 100 kg of kernels. In Thiruvannamalai district, where the seed material is brought from outside, transport charges of 700 INR for 100 kg of pods are added. In addition, commission charges of 200 INR as levied for 100 kg of pods, thus bringing the total to 800 INR as added cost. The cost of 100 kg pods ranges from 3500 to 4000 INR in the last three years, thus seed production at villages either through PDKV or seed village model will save at least 10% of seed cost in Tamil Nadu.

Promotion and formal recognition of informal seed sector

A policy document for the state of Tamil Nadu titled 'Groundnut cultivation and existing seed systems" was prepared and made available to the authorities. In this document, emphasis was given to recognize the informal seed sector to meet the seed demand of this crop in particular.

The semi-formal seed production system has been a successful model in the state of Karnataka to meet the seed demands of various crops, including groundnut. The same was given wide recognition at national seed program (NSP) thus encouraging the other states to follow this model of seed system. Currently many states in the country are implementing this model.

Capacity building

Farmers' training

A total of 4,267 farmers were trained during three years in the two states. In three districts of Tamil Nadu, a total of 2,711 farmers (including 998 women) were given training on various aspects of seed production, seed health and seed processing and storage. In Karnataka, a total of 1,556 farmers were trained on aspect of seed production and processing in 13 training programs organized over three years. UAS, -Bangalore has trained 1,356 farmers (including 221 women) while UAS-Raichur trained 200 farmers.

Local seed traders and processors

A total of 172 seed traders from both the states were trained in proper seed handling and storage. Seventy two seed traders in the three project districts of Tamil Nadu were trained in six training programs on aspects of seed handling, storage and processing. Ninety five seed traders were trained at a program organized at Chitradurga district of Karnataka.

Training course

A total of four training sessions were held. In Tamil Nadu, one training program on groundnut seed production was organized for extension officials, NGOs and private seed sector people. A total of 411 officials, including 72 women, were trained in production, processing, packing, labeling and storage aspects. In Karnataka, three training programs were conducted to train a total of 82 extension officials, NGOs and private seed sector personnel on aspects of quality seed production.

Farmers' day/field day/farmers' fair: A total of 87 field days on farmers' fields were conducted in eight districts of both the states in which 5,456 farmers have participated. In addition, two farmer's days and one farmer trade fair were organized at Coimbatore. A total of 2,804 and 2,727 farmers have participated in farmer's day and farmer trade fair, respectively. In farmers days conducted by UAS-Raichur, 2,100 farmers including (100 women) participated.

In Tamil Nadu, over 6000 farmers were made aware of improved groundnut varieties. A total of 1038 farmers were made aware as participant of PVS and paired comparisons and another 871 farmers were made aware of improved varieties through 18 field days conducted in farmers' fields. In addition, 5,531 farmers were reached through state and regional farmers' fairs.

In five districts of Karnataka over 5,000 farmers were directly reached and made aware of improved varieties; 819 farmers were reached through participation in PVS and paired comparisons and another 4,585 farmers from the nearby villages visited the farmers plots where improved varieties were cultivated during 69 field days conducted over three years.

Seed distribution to farmer-preferred groundnut varieties

During the project period, a total of 6,505 small seed samples ranging from 2- 10 kg pods of farmer-preferred groundnut varieties were supplied to the farmers. In Tamil Nadu, a total of 626 of 10 kg seed samples, 433 of ICGV 87846 and 193 of ICGV 00351 were distributed to the farmers in the three districts. In Tumkur, Chitradurga and Chickballpur districts of southern Karnataka, 10 kg of ICGV 91114 kernels was distributed to 330 farmers including 50 women. In Bagalkot district, UAS, Dharwad over 5,000 small seed samples of ICGV 00350 and GPBD 4 were distributed to farmers. In Raichur district, 549 small seed samples of farmer-preferred groundnut varieties were distributed to the farmers over three years.

Farmer awareness activities through print and electronic media

*Groundnut seed production manual in local languages:*Two groundnut seed production manuals titled 'Tips to produce quality seeds in groundnut' and 'Techniques to overcome seed viability in Rabi/Summer groundnut' were printed in local language (Tamil) and distributed to the trainees. A total of 6,043 copies of the said manuals were distributed over three years in three districts of Tamil Nadu. Groundnut seed production manual has been published in Kannada language by UAS, Bangalore for Karnataka state and also by USA, Dharwad. UAS, Raichur published 1000 copies of seed production manual in Kannada language and distributed to trainees.

Enhancing local-level awareness of released varieties: Two pamphlets on farmer-preferred groundnut varieties namely, ICGV 87846 and ICGV 00351 were printed in Tamil to distribute to the farmers in three districts of Tamil Nadu. Pamphlets on the ICGV 91114 variety identified for southern Karnataka was published in Kannada language and distributed to farmers. The farmer-preferred varieties *viz.,* R-2001-2 and ICGV 00350 were short-listed and 5,000 copies of descriptors of these varieties were printed and distributed to farmers in Kannada language by UAS-Raichur.

Local print and electronic media: In Tamil Nadu farmer awareness activities were conducted through print and electronic media in local language. Seven shows in television were telecasted covering various aspects of groundnut cultivation and improved varieties, similarly three radio talks were broadcasted and three newspaper/popular magazine articles were published for the benefit of farmers. In addition through nine press briefings new varieties and practices in groundnut were communicated to the farmers. In Karnataka, four publications in print were brought-out on various aspects of new groundnut varieties and production practices.

Enhancing Groundnut Productivity and Production in Eastern and Southern Africa

Emmanuel Monyo (ICRISAT-Malawi); Albert Chamango; Francis Maideni (DARS-Malawi); Omari Mponda (DRD-Tanzania); Firmin Mizambwa (ASA-Tanzania); Manuel Amane (IIAM-Mozambique)

Summary

The Tropical Legumes II Project is a research and development initiative funded by the Bill & Melinda Gates Foundation. The project targets legumes that have high nutrients and commercial potential to fighting hunger, increasing income and improving soil fertility for the resource-poor farmers. Groundnut improvement and seed systems under this project is implemented by ICRISAT with full participation of three national programme partners in Malawi, Mozambique and Tanzania for groundnut breeding and Malawi and Tanzania for groundnut seed systems. There is strong involvement of public sector, private sector and non-governmental organisations. Major aim of the partnership is to enhance groundnut production and productivity in drought-prone regions by incorporating genetic resistance/tolerance to major yield- and quality-reducing constraints, improve seed availability and thus adoption of new varieties and building the capacity of partners for better utilization of integrated legume innovations, including affordable high-quality seed. The project focuses on farmer-participatory varietal selection, developing new drought-tolerant varieties and upgrading skills and capacity of NARS, including farmers. Under seed systems, the project's main focus is improving the availability of foundation seed; designing, testing and implementing seed production programs tailored to varying client needs; designing, testing and implementing seed delivery and marketing arrangements tailored to varying client needs; enhancing local-level capacity to produce, deliver, store and market seed; and enhancing local level awareness of released varieties.

The project has recorded significant successes in all three countries. In Tanzania, variety traits preferred by farmers were documented and five new groundnut varieties were released – three of them with rosette resistance and all of them recording more than double the yields of the local varieties. In Mozambique similarly farmer-preferred variety traits were documented and six new groundnut varieties released, three early maturing with combined rosette and early leaf spot (ELS) resistance.

Finally, one groundnut variety was identified for possible release in Malawi and has been placed on the pre-release list. Sustainable basic seed provision system that involved a seed revolving scheme was designed and pursued to meet the needs of basic seed provision of released varieties in Malawi. Alternative smallholder seed delivery schemes in both countries that included working through cooperative societies in Tanzania and farmer associations in Malawi; farmer field schools in both Malawi and Tanzania; and rural community structures like schools, seed villages and churches in both countries facilitated access to good quality seed.

Farmer field schools approach is one of the most popular smallholder seed provision models in Malawi delivering improved groundnut seed to more than 100,000 households in that country and Tanzania over the past three years. It is estimated that the total seed produced in these two countries (if availed in 2 kg small seed packs) would benefit a total of 1,587,000 individual farmers in the two countries.

Background

The yield of groundnut in the region is limited by four major constraints. The first is the low yielding potential of currently available varieties. In Malawi, for example, the local variety Chalimbana takes six months to reach maturity and even under good agronomic practices it will not give more than 800 kg per ha compared to 1700- 2500 kg per ha possible from elite varieties. The situation is similar in Mozambique where the local variety Bebiano Blanco and in Tanzania where Red Mwitunde are the popular farmer varieties in large parts of the country. Biotic stresses are the other major constraint to farmers achieving maximum yields. Rosette, ELS, aflatoxin, and rust are the major diseases contributing to groundnut yield losses in the region. In seasons of rosette epidemic, the entire crop can be lost to the disease though in the majority of years approximately 30% average yield loss from all diseases combined is common. It has been estimated that in Malawi alone, approximately $12 million is lost annually from the combined effect of ELS and rosette. Finally, drought due to the erratic nature of rainfall in the groundnut production agro-ecological zones in the three target countries is a major abiotic threat. We have production areas that can accommodate three, four, and five months of growing season and varieties are targeted to these different agro-ecologies.

Socio-Economics/Targeting

Groundnut production trends in the three target countries

Groundnut production in the three countries presents an upward trend. For Malawi data from 1982/83 reveal an area growth from about 155,539 ha to 266,503 in 2006/07. This was accompanied by a production growth from 57,282 metric tons to 267,077. There was also a significant growth in production per unit area from an average yield of 368 kg per ha to 1002 kg per ha (Table 3-1).

This came at a time of heightened groundnut improvement program for Eastern and Southern Africa based at the Chitedze Research Station in Malawi. Achieved grain yields across districts and agro-ecologies in different parts of the country clearly demonstrated the need for targeting varieties to their appropriate zones of adaptation. Whereas better endowed agro-ecologies like the Central plateau (comprising Mchinji, Dowa, Dedza, Lilongwe) and the high altitude areas of Rumphi, Shire Highlands, and Phalombe managed above 1 MT per ha on farmers fields and could utilize full season varieties like CG7, and Nsinjiro to maximize production we realized the need for early maturing or short duration varieties for the low altitude short season agro-ecologies normally found in Chitipa, Karonga, lower Thyolo, Mangochi, Machinga, Balaka, Neno, Chikwawa and Nsanje (Table 3-2 less than 0.75 MT per ha).

Table 3-1: Groundnut trends in Malawi

Year	Area (1000 Ha)	Yield (Kg per Ha)	Production (1000 MT)
1982-83	156	368	57
1983-84	143	359	51
1984-85	136	457	62
1985-86	174	495	86
1986-87	208	419	87
1987-88	174	411	72
1988-89	140	249	35
1989-90	48	386	19
1990-91	69	439	30
1991-92	64	175	11
1992-93	60	523	31
1993-94	72	608	44
1994-95	86	335	29
1995-96	72	565	40
1996-97	86	667	57
1997-98	141	705	99
1998-99	171	725	124
1999-00	169	685	116
2000-01	181	814	148
2001-02	184	816	150
2002-03	221	871	192
2003-04	209	739	155
2004-05	234	572	134
2005-06	231	822	190
2006-07	267	1,002	267

Source: Computed from Malawi National Statistics Office (NSO), 2008

Table 3-2: Groundnut production trends in different agro-ecologies of Malawi

	2005/06			2006/07		
Rural Development Program /Agricultural Development Division	Area (Ha)	Yield (Kg per Ha)	Production (MT)	Area (Ha)	Yield (Kg per Ha)	Production (MT)
Chitipa	3 078	671	2 064	3 548	693	2 458
Karonga	4 603	687	3 160	3 243	582	1 888
KARONGA	7 681	680	5 224	6 791	640	4 346
Rumphi/N/Rumphi RDP	1 937	834	1 615	1 655	1 263	2 090
C. Mzimba/Mzimba	24 185	659	15 933	24 864	876	21 774
S. Mzimba						
Nkhata Bay	2 003	771	1 545	2 628	861	2 264
Likoma						
MZUZU	28 125	679	19 093	29 147	896	26 128
Kasungu	16 170	462	7 475	18 830	941	17 717
Mchinji	23 524	1 209	28 446	28 629	1 315	37 658
Dowa West/Dowa RDP	15 043	916	13 773	15 342	1 022	15 673
Dowa East						
Ntchisi	4 740	704	3 335	5 378	1 022	5 499
KASUNGU	59 477	892	53 029	68 179	1 123	76 547
Lilongwe West/Lilongwe	35 481	941	33 380	55 020	1 159	63 789
Lilongwe East						
Thiwi/Lifidzi						
Dedza Hills/Dedza	17 147	970	16 634	19 179	1 100	21 093
Ntcheu	12 138	855	10 380	12 409	963	11 946
LILONGWE	64 766	932	60 394	86 608	1 118	96 828
Nkhotakota	3 890	881	3 427	4 877	915	4 463
Salima	4 658	783	3 649	5 127	844	4 326
Bwanje						
SALIMA	8 548	828	7 076	10 004	879	8 789
Mangochi	15 924	677	10 785	16 251	746	12 127
Namwera						
Kawinga/Machinga	7 764	622	4 829	7 919	723	5 726
Zomba	8 026	713	5 719	8 832	780	6 885
Balaka	2 269	661	1 499	2 623	777	2 037
MADD	33 983	672	22 832	35 625	752	26 775
Shire Highlands/Blantyre	5 943	932	5 541	6 254	1 063	6 650
Phalombe	6 518	980	6 385	6 633	1 130	7 492
Thyolo	3 931	619	2 432	4 156	737	3 062
Mulanje	4 238	719	3 049	4 400	818	3 601
Neno	504	546	275	1 018	686	698
Chiladzulo	1 920	612	1 175	1 884	815	1 536
Mwanza	2 276	799	1 818	2 481	937	2 324
BLANTYRE	25 330	816	20 675	26 826	945	25 363
Chikwawa	1 595	676	1 078	1 514	708	1 072
Nsanje	1 791	436	781	1 809	680	1 230
SHIRE VALLEY	3 386	549	1 859	3 323	693	2 302
Total	**231 296**		**190 182**	**266 503**		**267 078**

Source: Computed from NSO (2008)

For Tanzania data from 1990-2008 also show an upward trend both in terms of area under production and yield. Area under production increased almost four fold in 18 years (110,000 – 415,000 ha) whereas production increased 5-fold (60,000 to 300,000 MT). Yields have also been increasing though not as fast as it was in Malawi (545 to 723 kg per ha). There was a sharp decline in production and yield during 2000 that was caused by drought. Yields dropped to as low as 444 kg per ha but immediately bounced back to 836 kg per ha and 945 kg per ha during the following two consecutive seasons (Table 3-3).

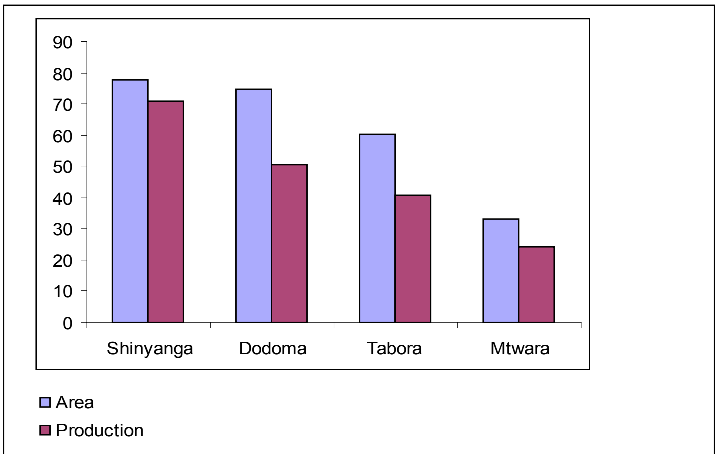
Table 3-3: Groundnut production trends in Tanzania

Year	Area (1000 Ha)	Yield (Kg per Ha)	Production (1000 MT)
1990	110	545	60
1991	110	636	70
1992	110	591	65
1993	110	636	70
1994	110	636	70
1995	113	637	72
1996	116	638	74
1997	116	621	72
1998	116	629	73
1999	116	638	74
2000	117	444	52
2001	247	836	207
2002	367	945	347
2003	348	459	160
2004	375	885	332
2005	409	718	294
2006	410	707	290
2007	415	723	300
2008	415	723	300

Source: Statistics Unit, Ministry of Agriculture, Food Security and Cooperatives (MAFSC), Tanzania (2008).

In order of importance, the largest groundnuts production regions of Tanzania are Shinyanga, Dodoma, Tabora and Mtwara accounting for over 60% of the national production. Mtwara and Western Shinyanga have slightly better rainfall distribution and can accommodate some of the medium duration Virginia groundnuts whereas Spanish early duration varieties are more adapted to the rest of the country (Figure 3-1).

Figure 3-1: Groundnut area (000 ha) and production (000 MT) in Tanzania (2001/02- 2004/05)



Source: MAFSC (2005).

Table 3-4 below presents area under groundnut in Mozambique. Similar to Malawi and Tanzania, there is an area increase trend from 2002 when the area was 329,000 ha to 2008 when the area reached 459,000 ha. About 99% of the area under groundnut is cultivated by small-scale peasant farmers on traditional farms and the crop is important as a subsistence food crop, oil extraction, as well as source of cash. The main varieties are farmer's local varieties, Bebiano Blanco, Mamane and Nematil. The availability of good quality seed is considered to be a pre-requisite to improve agricultural productivity. Generally, the use of inputs (including improved seed, P and K fertilizers) and equipment in agriculture is very low and this is reflected in crop yield. For southern Mozambique (Inhambane, Gaza and Maputo) the focus is on high yielding short duration varieties (90 – 110 days) with resistance to ELS and rust. For northern Mozambique (Nampula, Zambezia, Cabo Delgado) the major focus is on medium-duration varieties (110 – 130 days) with resistance to rosette, and ELS. For the whole country, the strategy is to provide varieties and agronomic packages targeting reduction of aflatoxin contamination.

Breeding

Varietal traits preferred by farmers

Farmer Participatory Variety Selection (PVS) gives farmers an opportunity to select varieties from a range of near-finished materials in the breeding process, which are then proposed for release. However, this farmer participatory exercise also gives breeders the opportunity to understand the criteria farmers use in the selection process and identify farmer and market preferences. For TL II, this activity was therefore implemented for three key reasons, namely: to identify local and market evaluative criteria for groundnut varieties, to determine the performance of promising varieties for release, and to identify farmer- and market-preferred varieties.

In all three countries the methodology used to elicit farmer selection criteria was the same though the number of varieties used in country studies and number of participating farmers differed according to availability of seed and farmers in participating communities. The procedure used in Tanzania will elaborate the methodology. A minimum of 10 varieties each for Spanish and Virginia groups were used in farmer evaluative trials. Entries were selected based on seed yield and a multiple of other desirable agronomic traits such as seed color, size, shape, and maturity range. These entries were evaluated in farmers' fields across 20 villages representing major groundnut growing areas in southern and central Tanzania.

Table 3-4: Area planted to groundnut (000 ha) in Mozambique

Type	Province	2002	2005	2006	2007	**2008**
Large-seeded	Niassa	6	9	8	10	11
	Cabo Delgado	26	38	22	38	27
	Nampula	27	30	31	32	38
	Zambezia	20	22	18	19	24
	Tete	16	24	15	16	25
	Manica	5	2	2	5	4
	Sofala	5	3	2	3	4
	Inhambane	7	2	0	2	2
	Gaza	4	1	1	0	1
	Maputo	1	1	0	0	0
	National	117	132	99	125	136
Small-seeded	Niassa	3	7	6	3	3
	Cabo Delgado	9	7	8	8	8
	Nampula	56	116	84	109	129
	Zambezia	17	28	22	31	45
	Tete	15	21	19	26	33
	Manica	7	11	12	15	9
	Sofala	4	5	7	5	9
	Inhambane	64	70	43	51	53
	Gaza	28	22	17	19	22
	Maputo	9	7	5	6	12
	National	212	294	223	273	323
Total		**329**	**426**	**322**	**398**	**459**

The trial was arranged in a randomized non-replicated block (mother trial) where each village comprised a replication. Two groups of 10 farmers in each village evaluated the mother trial. A subset of the trial (3 entries plus farmer's check) known as baby trials was given to five individual farmers to evaluate on their own fields. Direct ranking, pair-wise comparison and matrix ranking techniques were used to elicit farmers' variety preferences prior to harvest and at post-harvest stages, based on identified local evaluative criteria. After drying, plot yield data were collected and analyzed. The decision making criteria which farmers used in their choice and selection of varieties prior to harvest were plant vigour, disease resistance, pod size, pod filling, grain yield and maturity period. They also included such criteria as marketability and ease of plucking at harvesting and post-harvest stages.

At each village, each of the 10 varieties under evaluation was compared with the other and the local check. The number of times a select variety is chosen against all others is tabulated and total score per variety recorded. The varieties are then ranked on the basis of scores given. As can be seen in Table 3-5 above, using this pair-wise ranking methodology, ICGV-SM 99555, ICGV-SM 99557 and Pendo are ranked 1st, 2nd and 3rd, respectively.

Table 3-5: Results of pair-wise comparisons of Spanish varieties by farmers in Tanzania 2007-08

	Nangaramo	MMnemeka 2	Ndwika 1	Nawaje	Namarupi	Sululu	Total	Rank
ICGV-SM 01514	0	1	0	0	0	1	2	10
ICGV-SM 99555	8	6	8	4	8	7	41	1
ICGV-SM 99557	9	5	7	7	4	8	40	2
ICGV-SM 00530	6	4	5	6	7	7	35	4
ICGV-SM 99551	5	6	6	5	6	2	30	5
ICGV-SM 99529	2	3	4	8	4	3	24	6
ICG 12991	3	5	3	6	3	4	24	6
Nyota	4	3	3	2	3	2	17	9
Pendo	5	9	6	5	6	8	39	3
Dodoma Local	4	4	4	3	5	4	24	6

Another method used is to ask members of a farmer group in each village to select their 3 best varieties based on their own composite of preferred traits criteria. There is normally a lot of debate among group members in coming up with the 3 and in deciding which of the three is ranked the first. The number of times a given variety is selected as the most preferred is used to rank the varieties. Again, using this criterion, ICGV-SM 99555 and ICGV-SM 99557 took the top spot, followed by Pendo (Table 3-6). The fact that these two different methodologies came up with the same varieties is indicative of their farmer appeal.

Table 3-6: Results of direct ranking selection of three preferred Spanish varieties by farmers across on-farm trial sites, 2007-08 growing season in Tanzania

	Nangaramo	Mnemeka 1	Ndwika 1	Nawaje	Namarupi	Mungano	Sululu	Makoja	Mungano	Makulu	Total
ICGV-SM 01514											
ICGV-SM 99555	3		1	2	3	1			2		6
ICGV-SM 99557	1	2			1	3	2	2			6
ICGV-SM 00530				1			3				2
ICGV-SM 99551	2	1	3					1			4
ICGV-SM 99529					2					2	2
ICG 12991			2								1
Nyota				3					3		2
Pendo		3				2	1		1	1	5
Dodoma local								3		3	2

Table 3-7: Farmers’ variety trait preferences for groundnut

Variety/line	Pod size								Pod filling								Maturity								Marketability					
	Nangaramo	Mnemeka 1	Ndwika 1	Nawaje	Namarupi	Sululu	Total	Rank	Nangaramo	Mnemeka1	Ndwika 1	Nawaje	Namarupi	Suululu	Total	Rank	Nangaramo	Mnemeka 1	Ndwika 1	Nawaje	Namarupi	Sululu	Total	Rank	Nangaramo	Ndwika 1	Nawaje	Sululu	Total	Rank
ICGV-SM 01514	3	2	2	3	1	3	14	8	3	3	4	3	3	3	19	5	5	5	4	4	4	3	25	5	3	2	4	2	11	5
ICGV-SM 99555	4	3	4	2	3	3	19	3	5	4	3	2	3	4	21	4	3	5	4	3	4	5	24	6	4	4	4	5	17	1
ICGV-SM 99557	4	5	4	3	5	4	25	1	5	5	5	4	5	5	29	1	3	5	5	5	5	4	27	4	4	4	4	5	17	1
ICGV-SM 00530	4	3	3	3	3	1	17	5	3	3	1	3	4	3	17	6	3	3	2	5	5	4	22	8	2	3	4	2	11	5
ICGV-SM 99551	3	2	5	2	3	3	18	4	3	4	4	5	3	3	22	3	4	3	4	3	5	4	23	7	2	4	3	2	11	5
ICGV-SM 99529	2	2	3	4	2	2	15	7	2	4	3	3	5	2	19	5	3	4	4	3	3	3	20	9	4	4	3	4	15	3
ICG 12991	3	1	2	3	4	3	16	6	4	3	2	3	3	4	19	5	5	4	3	5	3	5	25	5	3	2	4	3	12	4
Nyota	1	1	1	1	2	1	7	10	3	5	4	3	1	3	19	5	5	5	5	5	5	5	30	1	1	2	2	3	8	6
Pendo	3	3	3	3	5	4	21	2	5	4	3	4	5	5	26	2	4	5	5	5	5	5	29	2	4	4	4	4	16	2
Dodoma local	2	2	2	2	3	2	13	9	3	5	5	5	5	3	26	2	5	4	5	4	5	5	28	3	2	3	3	4	12	4

Finally, the variety choices are converted into traits of preference (Table 3-7). Overall grain yield is regarded by farmers as a composite trait encompassing several traits of appeal to them. In addition to this and because of the fast growing groundnut confectionery market, uniformity of the grain for industrial uses as determined by pod filling and grain size and the attractiveness of the grain for market (marketability) forms a significantly important criteria for variety preference. Both pod filling, pod/grain size and market appeal was found in ICGV-SM 99557 which again ranked top. Considering variety marketability alone, ICGV-SM 99557, ICGV-SM 99555 ranked 1st, followed by Pendo. In addition to guiding the breeder about trait preferences, this methodology was also of great assistance in the identification of the varieties that ended up being released in both Tanzania and Mozambique. Varieties for release were also identified in Malawi – which should be released before the end of year 4 of the project. Trait preferences were therefore summed up as high yields, early maturity in the predominantly short-duration environments, large seeds for the European export and confectionery markets, small-seeded for local use in Mozambique and industry use in South Africa (chocolate coated nuts), tan color for both Malawi and Mozambique and both tan and red colored varieties for Tanzania. Farmers in all countries mentioned disease resistance but as long as the variety was high yielding – it was assumed disease is no longer an issue.

Fast-track release of 'on-the-shelf' varieties

PVS was used as a tool for fast-track release of elite improved varieties which were in the program but not yet released. This involved the evaluation of more than 148 groundnut mother trials (36 YR1, 60 YR2, 28 YR3, and 24 YR4) and 440 baby trials (120 YR1, 174 YR2, 74 YR3 and 72 YR4) in Malawi, 60 mother trials and 300 baby trials in Tanzania, and 48 mother trials and 162 baby trials in Mozambique. This evaluation resulted into the following successes in the three countries:

Tanzania

Five new varieties were released in 2009. ICGV-SM 99555 or Naliendele 2009 and ICGV-SM 99557 or Mangaka 2009 early maturing (90-100 days) drought and rosette disease resistant (Spanish bunch);. CG 7 or Mnanje 2009, ICGV-SM 01721 or Masasi 2009 and ICGV-SM 01721 or Nachingea 2009 medium maturity (100 – 110 days), high yielding (up to 2.5 MT per ha). Masasi 2009 is also resistant to rosette. All three of them are Virginia bunch types.

Mozambique

Six improved new varieties were released in June 2011. Five of them are Spanish and one Virginia. ICGV-SM 01513, ICGV-SM 01514 are early maturing with combined rosette and ELS resistance, ICGV-SM 99541, ICGV-SM 99568 are early maturing with rosette resistance and JL 24 is early maturing good taste. CG 7 is medium maturing Virginia type. All of them have the potential to double the yields of the farmer's local which is currently popular throughout the country providing just 700 – 800 kg per ha.

Malawi

Two new varieties ICGV-SM 96714 and ICGV-SM 99567 (Spanish) and two Virginia ICGV-SM 01708 and ICGV-SM 01728 are under pre-release in Malawi and they have been identified on the basis of farmer and market preferences. These will be presented to the technology clearing committee sometime this year for release

New high yielding varieties developed

ICRISAT maintains a regional groundnut improvement centre at Chitedze Research Station in Malawi from where NARS are supplied with their germplasm requirements. Over the past three years of Phase 1, a total of more than 1600 new breeding lines have been availed to NARS in Tanzania, Malawi and Mozambique for evaluation against Groundnut Rosette Disease (GRD), Early Leaf Spots (ELS), rust, aflatoxin and drought to identify durable sources of resistance. The following sources have been identified and are currently in use for hybridization to develop mapping populations for QTL identification with support from TL I.

Sources of rust resistance; 92R/70-4, ICGV 94114, ICGV-SM 86021and ICGV-SM 02536 which combines rust and ELS. Additional rust resistant lines found from the germplasm reference set includes: ICGV 02194, ICG 11426, ICGV 01276 and ICGV 02286;

- Sources of rosette resistance: ICG 14705, ICG 15405, ICG 13099, and ICG 9449 identified from the groundnut reference set;
- Sources of ELS resistance identified from the groundnut reference set: ICG 5663, ICG 4156, ICG 721, and ICG 9905; and
- Sources of drought resistance; ICG 14390, ICG 14778, ICGV SM 00537 and ICGV SM 03535 identified from field trials.

An average of 20 to 25 sets of trials was dispatched annually to collaborating partners in Malawi, Mozambique and Tanzania for on-station evaluation against various stresses. These trial sets normally includes: Elite short-duration groundnut variety trials (25 genotypes), Elite Virginia bunch drought resistant groundnut variety trial (20 genotypes), Elite Spanish bunch rosette resistant groundnut variety trial (25 genotypes), Elite Spanish bunch drought resistant groundnut variety trial (20 genotypes), and Elite rust resistant groundnut variety trial (16 genotypes) etc. For Malawi, these trials are normally established at Chitedze, Chitala, Kasinthula and Ngabu. In Mozambique they are established at Nampula, Zambezia, Chokwe and Inhacoongo (Inhambane) whereas in Tanzania trials are conducted at Naliendele, Nachingwea, Hombolo, Makutopora, Bihawana and Tumbi Research Stations. Trials are jointly monitored by ICRISAT and concerned NARS and data reported in appropriate annual planning and review meetings for the project. For the entire period, over 100 international/regional trial sets including varieties and advanced/elite lines were distributed for evaluation between 2008 and 2010. Similarly, the groundnut reference set (259 varieties) and recombinant inbred lines - RILs (300) were distributed for drought and disease phenotyping in Malawi and Tanzania in conjunction with TLI. Performance of some of the trial sets in select partner research stations is highlighted in the annex tables.

New crosses at ICRISAT-Malawi

Hybridization activities have been conducted at Chitedze Research Station in Malawi from the beginning of the project, 2007 to date. Main aspects of the hybridization program include the following:

- Incorporation of rust resistance. Four mapping populations are currently at F6. Phenotyping and genotyping of these populations with 5000 available SSR markers will begin in 2012;
- Incorporation of ELS resistance. The only ELS resistant varieties (two of them) were released this year in Mozambique otherwise there was none for the whole region. The program now has three mapping populations currently at F6. New populations have been initiated from better sources of resistance identified from screening of the groundnut reference set;
- We have reached BC3F1 populations of several farmer-market preferred varieties for incorporation of disease resistance. These include such popular varieties as CG 7, JL 24 and Pendo that are released in all three countries but susceptible to rosette, ELS and rust. We have started with rosette incorporation; and
- The program currently maintains more than 3500 progenies for rust, 1500 progenies for ELS and 400 for rosette from segregating populations (F3 – F6) developed for variety improvement through pedigree breeding.

Upgrade skills and capacity

Infrastructure for active breeding program have been developed in all participating countries as follows: In Tanzania, facilities now exist for green houses for disease screening, fridges for preservation of samples (seed and disease), rainout shelter and Leaf Area meter for drought screening and Spad meter for chlorophyll measurements in drought screening trials. In Malawi the NARS have similarly been equipped with a rainout shelter, two glass houses, one portable weather station and irrigation pump Malawi to help them maintain offseason breeding nurseries. In all the countries on the job training and academic training to MSc degree level complemented the infrastructure developed. The program trained one Tanzanian to MSc degree level at Sokoine University of Agriculture. Training on groundnut hybridization techniques, design of experiments and statistical data analysis, disease screening and use of the infector row technique benefited seven research technicians from Malawi (3), Tanzania (2), and Mozambique (2). Three scientists one each from the partner countries attended the statistical data analysis training conducted at ICRISAT Malawi.

On awareness creation, a total of 35 – 40 farmer field days were conducted annually in Malawi and 20 each in Tanzania and Mozambique. In Malawi about six thousand (6000)

Flyers on groundnuts management practices including options for the management of rosette and aflatoxin were produced and distributed during field days in Kasungu, Nkhotakhota and Mchinji. Three quarters of these were in Chichewa (the local language) – some of them specifically focussing on the results of studies conducted on farmers' fields as a way of bringing back to the farmers elements of the evaluations that is required for further analysis. In this way farmers contribute directly to the ongoing research. In Tanzania, 4000 booklets describing good agronomic practices and methods for good quality seed production were produced and disseminated. Finally both Tanzania and Malawi printed flyers (4500) on farmers and market preferred groundnuts varieties in three categories: description of released varieties, description of promising materials under farmer evaluation and results of participatory variety selection from previous seasons.

Lessons learned – groundnut improvement

1. Scientist-farmer partnership in agricultural research and development is crucial in bringing about desired changes in the agricultural research and production scenario in the country;
2. Farmers' advocacy of new varieties and technology is essential to bring about changes in existing policies and large scale adoption;
3. Sustained seed support is essential for large area coverage by FPVs and resultant enhanced productivity in groundnut; and
4. Policy makers, administrators, scientists, farmers and formal and informal seed sectors need to come together to initiate a silent revolution in rain-fed agriculture.

Seed Production and Delivery Systems

The inability of existing seed systems to provide small-scale farmers with access to improved groundnut seed is conditioned by a number of constraints. First, public-sector seed production has not been able to meet the demand for new varieties. Priority for the initial quantities of Foundation Seed stocks is generally given to more commercial crops, such as hybrid maize. The private sector also has shown little interest in entering the legume seed industry, particularly groundnut, due to low profitability. Groundnut has a very high seeding rate (approx. 100 kg per ha) and low seed multiplication ratio (approximately 1:10). Since it is a self-pollinated crop, farmers normally resow varieties multiple times once they receive the initial germplasm, thus making it difficult for the private sector to make profit marketing groundnut seed. Many seed enterprises, especially legumes, have been supported by non-governmental organizations and tend to be subsidized and inefficient. This combination of poor public-sector performance, lack of private sector interest, and reluctance to invest, has led to a void in seed supply systems that need to be filled.

Seed production and delivery strategies

The project embarked on three main strategies for seed provision – addressing the needs for Breeder Seed, Foundation Seed and Certified Seed.

Breeder Seed

Breeder Seed provision is the responsibility of the breeder and therefore efforts have been directed to making sure that seed is produced at all major research centers under the good eye of the breeder. In Malawi the main activities for Breeder Seed is centred around the ICRISAT and NARS breeding activities at Chitedze Research Station. From barely meeting obligations by ensuring availability of 0.5 – 1.0 MT Breeder Seed per annum, the combined efforts of ICRISAT and NARS are currently providing 27 MT of the five released popular varieties (Nsinjiro, CG 7, Chitala, Kakoma and Baka) in Malawi each season (about 5 MT each). Similarly, there was only one popular variety Pendo in Tanzania until 2009. Breeder Seed production activities of this variety were spread across three major research stations and one farmers training center (FTC) – Naliendele and Nachingwea in the Southern Zone and Makutopora and Bihawana FTCs in the Central Zone. A target of a minimum of 1 MT per center guaranteed 5 MT per year for the variety Pendo.

Foundation Seed

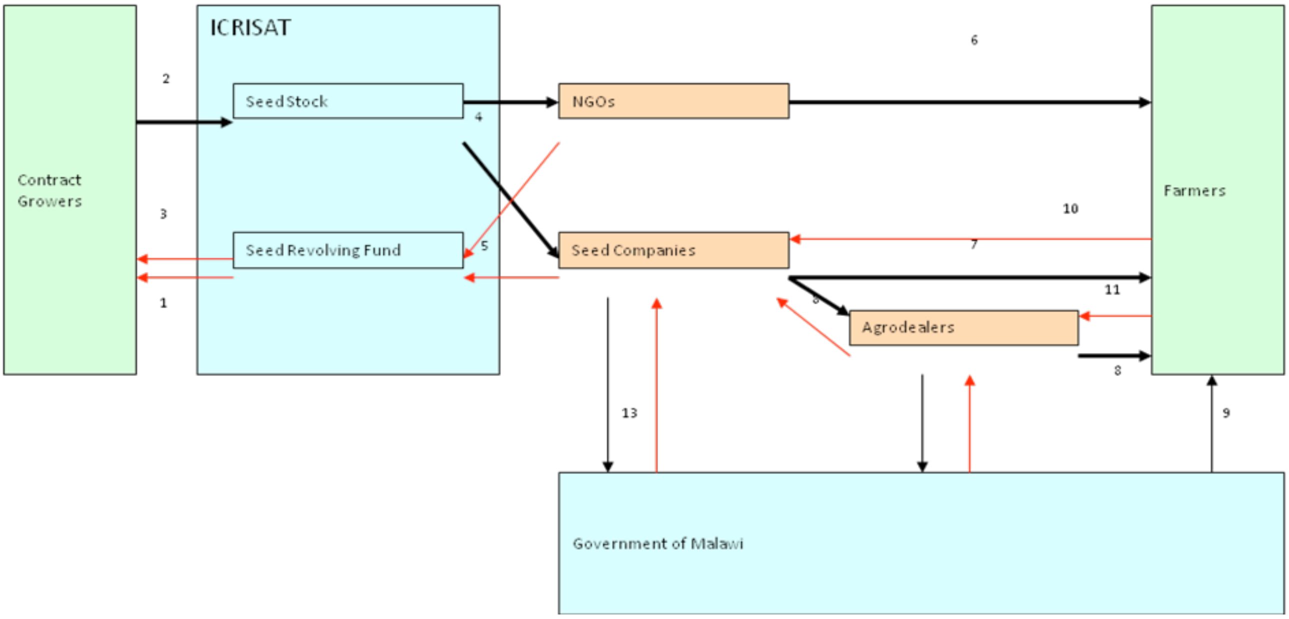
Two strategies were pursued for Foundation Seed provision. The first is contract farmers with a track record of successful delivery implemented in Malawi and Farmer Field Schools and Farmer Groups implemented both in Malawi and Tanzania. This came about as a result of long-term training of farmers through this project. The successful farmers were facilitated through an initial seed grant and after it was proved that they have a reputation to deliver they were given contracts as seed growers. Each season the selected farmers obtain new breeder seed from research and sign a contract to produce foundation seed. The Farmer groups for Malawi are those linked to the National Association of Smallholder Farmers in Malawi (NASFAM) whereas those for Tanzania are linked to the Agricultural Seed Agency (ASA).

Successful farmer field school members are also inducted into the scheme in both countries. Another successful Foundation Seed provision scheme in Malawi is the seed revolving fund scheme run by ICRISAT (Figure 3-2). This was initiated by ICRISAT in 2001 through a onetime financial grant from USAID and it is running to-date without injection of any more funds. Since its inception, the scheme has delivered more than 996 MT of Foundation Seed and 113 MT Breeder Seed. Realizing that the scheme has been in operation for the past 9 years, we have been meeting the Malawi Breeder and Foundation seed requirements at a rate of approximately 100 MT Foundation Seed and 12 MT Breeder Seed per season. This seed volume is enough to plant 1,250 ha of land to produce certified seed each season. Assuming 0.1 ha per farmer in Malawi due to their small plots, the scheme alone has been able to supply the seed requirements of 156,250 farming households each year. Taking cognizance of the fact that the major source of seed for groundnut farmers is another farmer, this number of farmers reached can easily be multiplied 5-fold as a result of farmer-to-farmer seed supply.

The scheme operates as follows: ICRISAT selects out-growers and gives those seed on credit, funded by the Revolving Fund; then at the end of the season the farmer sells the produced seed to ICRISAT. ICRISAT pays the farmer the contract price per kg of seed using the money from the Revolving Fund; ICRISAT then sells the seed to seed companies and/or NGOs. Proceeds received from buyers go back to replenishing the revolving fund. ICRISAT tries to sell seed to only those organizations that will further multiply the seed though some NGOs give away seed to farmers in certain areas and seed companies may sell some of the seed directly to farmers or through agro-dealers. In many instances the farmers or NGOs who procure this source seed for further multiplication.

Through the input subsidy program, government provides farmers with vouchers to purchase seed and farmers purchase seed from seed companies and pay using cash plus the voucher (subsidy is partial) or, farmers purchase seed from agro-dealers and pay using cash plus the voucher. The agro-dealer collects the redeemed vouchers and gives them to the government who pays the value of the vouchers to the agro-dealer. Finally, the seed company collects the redeemed vouchers and gives them to the government who pays the value of the vouchers to the seed company

Figure 3-2: The Malawi model of the seed revolving fund



The bold black arrows indicate the flow of seed and the red arrows indicate the flow of cash in the system

Certified Seed

Using the power of collective action, farmer organizations like NASFAM in Malawi and Farmer Cooperatives in Tanzania support their memberships to produce Certified Seed which they buy. For NASFAM, making sure that Certified Seed reaches their membership is important to make sure they are able to meet the quality standards of their groundnut export market. It is a well known fact that if one goes to the market, one gets better quality by asking for a particular variety than just asking for groundnut. A groundnut market dominated by specific varieties is therefore a more active market. This naturally demands a more vibrant seed system.

Alternative seed production arrangements

Beyond Breeder and Foundation Seed to solve the bigger problem of seed availability to smallholder farmers, the project embarked on certain arrangements to ensure availability of seed. In Tanzania this involved more than 100 farmer groups actively involved in seed production and in Malawi the system included farmer clubs, farmer field schools and farmer marketing groups linked to NASFAM. In Tanzania this resulted in the production of a total of 376 MT of good quality seed since the inception of the project whereas in Malawi these efforts resulted in the production of more than 2,808MT of good quality seed (Table 3-8). In Malawi it involved more than 450 farmers linked to the NGO CARE, 233 farmers linked to NASFAM, and 73 farmers linked to the Millenium Villages project, all distributed across different districts where TL II is intervening through groundnut.

For sustainability, it is also important that the private seed sector becomes involved. In Malawi, for example, stimulated by the government input subsidy program, SEEDCo, which is one of the largest seed companies in the region, is actively involved in groundnut seed production and marketing. In Tanzania, ASA started active involvement in groundnut seed production two years ago when enough volumes of Breeder Seed started becoming available. ASA injects approximately 100 MT groundnut seed into the seed market annually. This is a relatively small amount given the seed rate of the crop but it is a good beginning that the private sector is sowing interest.

Table 3-8: Seed production achievements

Season	Variety	Quantity (MT)	Total
Malawi			
2008	CG 7	211	256
2008	Chalimbana	45	
2009	CG 7	420	550
2009	Chalimbana	110	
2009	ICGV-SM 90704	20	
2010	CG 7	1640	2002
2010	Chalimbana	200	
2010	ICGV-SM 90704	162	
Malawi total		2808	**2,808**
Tanzania			
2008	Pendo	35	35
2009	Pendo	150	150
2010	Pendo	191	191
Tanzania total		376	**376**
Grand total			**3,184**

Diffusion, marketing and institutional arrangements for seed

Farmer marketing groups have been established in Tanzania - Mpeta, Mnanje B and Likokona - while seed production groups have been established in three districts of Malawi - Mchinji (19), Nkhotakota (28), and Zomba (3). In addition to the supply of the required variety and class of seed to growers and traders, they are also supported by capacity building and farmer-friendly literature in local vernaculars on Integrated Crop Management and seed production, processing, storage and marketing skills (especially traders and seed entrepreneurs). Seed marketing is handled by NASFAM in Malawi, and ASA in Tanzania. These agencies offer smallholder farmers seed production contracts to produce Certified Seed under joint ICRISAT-NARS supervision, which is then bought back by these agencies. The national seed services of each participating country do independent inspections to assure quality.

Malawi

In Malawi, ICRISAT, in collaboration with NASFAM and MVP, has established 48 seed production groups in Mchinji and Nkhotakota and two additional groups, one in each of the districts of Dedza and Zomba. The groups in Mchinji are already mature regularly producing seed on contract for ICRISAT and other interested NGOs and/or private sector. Others are still at seed production level and dependent on project-based support market to sell their produce as seed; otherwise they sell most of what they produce as grain. In addition, 150 farmers in Kasungu from Traditional Authorities of Kaomba, Mwase and Njobwa, in collaboration with ICRISAT and CARE, have been issued groundnut Breeder Seed of ICGV-SM 90704 and ICGV-SM 99568 to produce Foundation Seed under formal contract. What is interesting about these smallholder contractual growers is the fact that 135 of them have smallholding each producing 0.5 ha seed but they have organized themselves into a farmer cooperative in order to take care of the costs involved in delivery of a contract.

Tanzania

TL II has contributed to the establishment of Mpeta, Mnanje, Likokona, Mikangaula, and Mangaka to become active marketing centers for groundnut. Farmer research groups members and other farmers in these villages now receive premium price for improved groundnut seed (Pendo) from traders. The seed markets development aspect of this activity is reported in more detail under ESA Objective 1 Targeting impacts.

Local capacity to produce, deliver, store and market seed

Five hundred and twenty seven officers, farmers and seed producers, 57 technicians, 141 extension officers and 46 farmer research group leaders were trained in seed production in Tanzania and Malawi.

Preparation and printing of groundnut seed production manual

A groundnut seed production manual in Chichewa was produced for Malawi and a similar manual for Tanzania is available in Swahili.

Encouraging private sector to engage in the sale of small seed packs

Two private seed companies in Malawi (Funwe Seeds and Seed Co) and four in Tanzania (ASA, Zenobia, Krishna, and Miombo Estate) have ventured into commercial seed production targeting smallholder farmers with 1-2 kg small seed packs. These companies though more popular for their sale of maize hybrids are being encouraged to include groundnuts into their list. The popular groundnut small pack is 2 kg because of the large seeding rate and the investment that will enable the farmer at least to know something about the variety being evaluated.

Degree training of NARS

One collaborator from Malawi (Wilson Chafutsa) pursued an MSc program with specialization in seed technology at the University of Malawi.

Local level awareness of released varieties

Farmer field schools, field days and seed fairs were carried out at selected learning centers annually. In Malawi, 35-40 farmers' field days were conducted each year by NARS and ICRISAT with partners since 2007 to upgrade skills of farmers and stakeholders on improved varieties and integrated crop management while soliciting feedback to improve the focus of the breeding program. Farmer field schools have also become an important tool for technology awareness. There are 360 active farmer field schools in the project sites in Malawi. In Tanzania field days (19 per season), open days and seed fairs (two per site per season), farmer field schools (80 in Tanzania) have become tools for regular project monitoring of activities.

More than 15,000 flyers describing groundnut have been printed in Chichewa and Swahili and distributed to farmers in project sites. Television and radio broadcasts with live interviews and newspaper articles about new varieties have become a norm throughout the project sites in Malawi and Tanzania. In addition, over 6,000 farmers (3,635 women and 2,365 men) were trained in improved technologies (improved varieties and integrated crop management - time of planting, plant population, weed management, harvesting and post harvest technologies including storage, and management of aflatoxin contamination).

Over 150 on-farm demonstrations of improved groundnut production technologies have been conducted since inception. One hundred extension officers and policy makers (40 women and 60 men) have been exposed to improved groundnut varieties and integrated crop management through national level field days. Two seed fairs, one in Nanyumbu at Mikangaula village (Tanzania) 18-20 December 2009 and another at Mkwajuni village in Tunduru (Tanzania) 05-08 January 2010 were organized. The event provided opportunities to share seeds and knowledge of various crops including groundnuts. The seed fairs created awareness to over 2,000 people. Leaflets and booklets on groundnut were provided for free to participants.

Lessons learned – groundnut seed systems

1. Marketing-related issues (both input and output markets) continued to emerge as a challenge to full utilization of the potential of legumes by smallholder farmers;
2. Project interventions that focused on affordable seed production and delivery systems have a better chance of surviving beyond the lifespan of the project;
3. Seed production on contract is profit motivated as farmers look at seed production as an enterprise; sustainable seed production by smallholders stands a better chance of success if complemented by functional seed and product markets for legumes;
4. There is a need for faster varietal testing and release systems to enhance the spectrum of varieties available to farmers;
5. Inadequate number of research and seed technicians available in ESA hampers progress of seed dissemination; and
6. Business-oriented smallholder farmers performed better in seed production, seed storage, and seed dissemination than food security-oriented farmers, and hence our efforts should emphasize involving such groups in seed systems.

Annex 3-1: Performance of elite groundnut varieties (kg per ha) at selected research station sites in Tanzania (2009/10 season)

Cultivar	Naliendele	Nachingwea	Ilonga	Hombolo	Mean
CG 7	532	510	1880	654	894
ICGV 90087	720	280	1133	416	637
ICGV 90092	481	225	573	375	414
ICGV 94114	720	582	867	561	682
ICGV-SM 01711	627	422	1000	765	703
ICGV-SM 02501	626	623	633	558	610
ICGV-SM 03701	683	370	900	526	620
ICGV-SM 86201	700	148	1500	620	742
ICGV-SM 90704	692	582	967	512	688
ICGV-SM 99568	600	175	1300	383	614
PENDO	723	718	2533	763	1184
Mean	646	421	1208	557	
CV %	24.7	35.7	37.6	28.5	
LSD	272	256.1	978.6	270	
P=0.05	**NS**	**	*	**NS**	

Annex 3-2: Performance of Virginia groundnut varieties (kg per ha) at select research station sites in Tanzania (2009/10 season)

Cultivar	Naliendele	Nachingwea	Makutopra	Mean
CG 7	1303	1491	592	1129
ICGV-SM 01709	1162	1953	132	1082
ICGV-SM 01711	1663	1334	469	1155
ICGV-SM 01721	1586	1805	519	1303
ICGV-SM 05606	1731	1598	693	1341
ICGV-SM 06725	1706	813	232	917
ICGV-SM 90704	988	1453	283	908
Mean (20)	1465.45	1194.05	340	
CV (%)	9.4	20.6	29	
LSD	387.8	691.7	276.6	
P=0.05	**	**	**	

Annex 3-3: Regional elite groundnut variety trial-Virginia Bunch (Chitedze Research Station, Malawi) 2009/10 Season

Cultivar name	Final plant stand	Pod yield (kg per ha)	Kernel yield (kg per ha)	yield % of ICGV-SM90704	Haulm yield (kg per ha)	Days to 75% flowering	%wt on sieve 19	% wt on sieve 15	ELS 1	ELS 2	Shelling percentage	100 seed mass (g)
CG 7	74	3421	2764	149	1975	43	71.88	87.16	2	3	81.94	79.5
Chalimbana 2005	60	2649	2058	111	1480	46	80.1	85.4	2	3	78.09	65.71
ICGV-SM 01709	62	2680	2195	118	1225	45	47.27	81.79	2	3	81.89	55.48
ICGV-SM 01711	69	2883	2398	129	1453	46	63.06	82.57	2	3	82.66	61.18
ICGV-SM 01721	60	2987	2515	136	1290	43	76.25	83.49	2	3	83.63	72.09
ICGV-SM 01731	71	2523	1910	103	1257	46	68.21	82.34	2	3	75.98	62.87
ICGV-SM 02712	51	2641	1951	105	1658	48	57.19	78.94	1	3	74.66	54.6
ICGV-SM 02724	63	2843	2320	125	1323	48	64.21	83.92	1	2	80.5	59.5
ICGV-SM 03590	64	2617	2149	116	1477	47	36.43	77.03	1	3	81.23	57.7
ICGV-SM 03707	61	1868	1468	79	1828	39	56.39	79.82	3	3	78.81	49.61
ICGV-SM 03708	58	2957	2377	128	1134	50	68.6	82.07	2	3	80.17	62.36
ICGV-SM 03709	51	2527	1854	100	264	40	58.98	80.2	2	3	74.11	61.35
ICGV-SM 03710	36	1779	1450	78	1984	55	62.04	80.01	3	4	77.61	56.15
ICGV-SM 05558	60	2684	2131	115	1367	40	58.86	82	2	3	79.2	59.88
ICGV-SM 05582	45	1738	1343	72	1277	46	53.7	80.63	2	3	78.3	55.09
ICGV-SM 05606	51	2426	1939	105	1774	44	67.18	83.2	1	4	80.7	66.48
ICGV-SM 05693	57	3216	2596	140	1512	47	70.06	84.45	2	3	79.77	66.83
ICGV-SM 06725	55	2736	2273	123	503	43	66.4	82.09	2	3	82.76	61.86
ICGV-SM 07593	49	2609	2199	119	1901	47	54.43	84.91	3	4	85.1	75.84
ICGV-SM 90704	59	2426	1853	100	623	44	40.28	76.53	2	3	76.39	52.26
Grand Mean	**58**	**2610.5**	**2087.15**		**1365.25**	**45.25**	**61.076**	**81.9275**	**1.875**	**3.2249**	**79.675**	**61.817**
FPr	**0.02**	**0.664**	**0.651**		**0.62**	**0.143**	**0.016**	**0.048**	**0.157**	**0.953**	**0.352**	**0.024**
CV (%)	**12.02**	**23.55**	**25.77**		**47.38**	**6.09**	**13.11**	**2.7**	**28.58**	**26.59**	**4.64**	**8.77**
SED	**8.217**	**728.2**	**637**		**766.1**	**3.266**	**9.485**	**2.619**	**0.6348**	**1.0155**	**4.376**	**6.423**

Annex 3-4: Regional elite groundnut variety trial - Spanish Bunch (Chitedze Research Station, Malawi) - 2009/10 Season

Cultivar name	Final plant stand	Pod yield(kg per ha)	Kernel yield(kg per ha)	yield as % of JL 24	Haulm yield(kg per ha)	Days to reach 75% flowering	%wt on sieve 19	% wt on sieve 15	ELS 1	ELS 2	Shelling percentage	100 seed mass(g)
ICGV 94139	91	2752	1854	125	1693	46	56.66	89.96	4	8	68.6	45.54
ICGV-SM 00537	72	2401	1631	110	1163	44	51.48	101.16	4	9	68.15	53.02
ICGV-SM 01514	75	1815	1186	80	526	46	26.53	67.39	4	5	65.08	40.52
ICGV-SM 03513	85	1862	1334	90	1756	44	14.79	74.57	4	6	69.95	33.03
ICGV-SM 03516	77	2317	1565	105	755	44	35.14	101.43	6	9	68.28	48.05
ICGV-SM 03517	73	2007	1135	76	1200	43	31.23	101.24	5	9	57.97	43.08
ICGV-SM 03520	83	2486	1701	115	2204	44	29.46	85.51	5	8	67.5	43.7
ICGV-SM 03530	61	1588	1054	71	985	41	51.7	99.23	5	10	67.5	41.97
ICGV-SM 03532	72	2264	1622	109	1451	45	42.02	89.72	5	9	71.57	40.27
ICGV-SM 05711	81	1505	1060	71	552	45	29.78	86.29	4	7	69.43	26.15
ICGV-SM 05723	76	3297	2373	160	1526	44	86.94	98.03	5	8	73.7	51.15
ICGV-SM 05725	76	1896	1424	96	2430	44	73.31	91.1	5	8	74.26	42.9
ICGV-SM 05733	77	1541	1168	79	870	45	31.08	91.16	5	7	73	34.39
ICGV-SM 05738	90	1957	1231	83	652	39	82.07	100.15	4	5	62.53	52.64
ICGV-SM 05756	79	1565	1096	74	701	45	45.02	90.12	4	6	70.03	41.98
ICGV-SM 99537	79	3303	2042	138	1895	43	60.26	125.16	3	8	61.25	38.49
ICGV-SM 99551	88	2376	1495	101	1590	43	53.92	105.56	4	7	62.71	44.77
ICGV-SM 99566	70	2028	1451	98	-36	43	57.32	91.25	5	8	70.63	48.25
ICGV-SM 99568	69	2388	1810	122	1970	42	56.59	89.09	4	8	76.17	57.57
JL 24	99	2050	1484	100	730	47	51.4	93.6	4	6	72.15	43.28
Grand Mean	**79**	**2169.9**	**1485.8**		**1230.65**	**43.7505**	**48.335**	**93.586**	**4.37505**	**7.4999**	**68.523**	**43.5375**
FPr	**0.31**	**0.737**	**0.888**		**0.619**	**0.061**	**0.117**	**0.685**	**0.079**	**0.02**	**0.341**	**0.005**
CV (%)	**12.22**	**29.66**	**32.21**		**65.17**	**3.17**	**25.23**	**18.27**	**14.4**	**11.48**	**8.04**	**8.12**
SED	**12.42**	**832.5**	**618.9**		**1037**	**1.794**	**15.78**	**22.11**	**0.815**	**1.114**	**7.13**	**4.574**

Annex 3-5: Regional elite groundnut variety trial - Spanish Bunch (Chitedze Research Station, Malawi), 2009/10 Season

Cultivar name	Final plant stand	Pod yield (kg per ha)	Kernel yield (kg per ha)	yield as % of JL 24	Haulm yield (kg per ha)	Days to 75% flowering	% wt on sieve 19	% wt on sieve 15	Shelling %	ELS 1	ELS2	100 seed mass(g)
ICGV 94139	94	2462	1640	103	1619	46	47.69	86.71	67.72	3	8	43.37
ICGV-SM 00537	71	2202	1527	96	1197	43	43.03	99.87	69.16	4	9	52.13
ICGV-SM 01514	73	2002	1375	87	711	45	25.01	67.02	69.11	4	5	42.2
ICGV-SM 03513	85	2119	1673	106	1567	43	17.88	71.59	75.89	4	6	34.95
ICGV-SM 03516	70	2072	1383	87	603	44	34.77	94.81	67.64	5	9	45.23
ICGV-SM 03517	67	2288	1363	86	1345	42	39.3	109.37	59.52	5	9	47.91
ICGV-SM 03520	80	2241	1428	90	1968	42	38.19	105.84	63.51	6	8	45.45
ICGV-SM 03530	61	1589	988	62	1159	42	53.15	102.08	65.8	5	9	40.9
ICGV-SM 03532	74	1868	1336	84	1086	45	44.86	92.94	70.79	5	8	37.26
ICGV-SM 05711	80	1994	1487	94	698	45	39.46	85.39	73.46	4	7	29.33
ICGV-SM 05723	79	3007	2159	136	1452	44	77.97	94.78	72.82	5	8	48.98
ICGV-SM 05725	79	1871	1416	89	2502	45	62.67	82.85	76.78	5	8	42.45
ICGV-SM 05733	78	2196	1527	96	911	46	45.09	84.63	71.1	4	6	37.32
ICGV-SM 05738	93	1932	1223	77	724	40	71.42	91.9	62.63	3	5	52.19
ICGV-SM 05756	79	1928	1329	84	846	45	52.4	92.96	69.99	4	6	43.76
ICGV-SM 99537	78	2777	1589	100	1956	43	58.89	129.13	56.5	3	7	34.26
ICGV-SM 99551	88	2739	1728	109	1735	43	61.3	108.4	62.68	4	7	46.55
ICGV-SM 99566	73	2269	1597	101	103	44	56.1	88.16	69.59	5	8	49.19
ICGV-SM 99568	71	1838	1364	86	1851	41	54.22	92.12	72.32	4	8	53.62
JL 24	97	2005	1585	100	579	45	43.3	91.15	77.05	5	7	43.69
Grand Mean	**79**	**2169.95**	**1485.85**		**1230.6**	**43.75**	**48.335**	**93.585**	**68.703**	**4.37505**	**7.5**	**43.537**
FPr	**0.217**	**0.92**	**0.981**		**0.42**	**0.095**	**0.198**	**0.483**	**0.488**	**0.093**	**0.006**	**0.001**
CV (%)	**11.69**	**31.51**	**35.08**		**59.96**	**3.42**	**29.79**	**17.26**	**9.48**	**15.12**	**9.65**	**7.22**
SED	**10.82**	**804.7**	**613.4**		**868.2**	**1.759**	**16.94**	**19.01**	**8.437**	**0.7785**	**0.8517**	**4.113**

Enhancing Groundnut Productivity and Production in Drought-Prone Areas of West and Central Africa

Bonny Ntare, Farid Waliyar (ICRISAT-Mali); Jupiter Ndjeunga, Abdoulaye Diarra, Abdoulaye Amadou, Ibro Abdoulaye (ICRISAT-Niger); Ondie Kodio, Youssouf Cisse (IER-Mali); Adamou Moutari, Marou Assane Zarafi (INRAN-Niger); Candidus A Echekwu, Ben Ahmed, Lora Alabi (IAR -Ahmadu Bello University- Nigeria); Mamoudou Togo (AOPP Systems-Mali); Karamako Sacko (EUCORD-Mali); Issoufou Maizama (Alheri Seeds-Dogondoutchi) Niger - Sanussi Mohammed (Bayero University of Kano-Nigeria), Balarabe Shehu (KNARDA-Nigeria); Mustapha Habib (KTARDA-Nigeria); Muhammad A Adamu (JARDA-Nigeria)

Socio-Economics/Targeting

This report presents the achievements from September 2007 to August 2011 of TL II targeting the promotion of groundnut varieties, building seed production and delivery systems and drawing lessons from interventions in Mali, Niger, and Nigeria. During the last four years of TL II project implementation, groundnut outlook (i.e. trends and market prospects) were studied and now better understood; project sites have been thoroughly characterized and varieties and traits preferred by farmers have been identified. Alternative seed supply systems have been characterized, tested and low cost and effective systems identified. The TL II project has generated some positive outcomes. In Niger for example, adoption of improved groundnut varieties has increased as a result of farmers' exposure and access to seed of improved varieties.

In addition, a total of four reports have been generated; these included:

a) A baseline report entitled *"Characterizing village economies in major groundnut producing countries in West Africa: Cases of Mali, Niger and Nigeria*
b) *Farmer preferences for groundnut traits and varieties in West Africa: Cases of Mali, Niger and Nigeria*
c) *Outlook for groundnut trends and market prospects in West and Central Africa*
d) *Early diffusion of groundnut varieties in the Dosso region in Niger*

A synopsis of results from the reports is presented below.

Outlook for groundnut trends and market prospects in Western and Central Africa

Western and Central Africa lost its world groundnut production and export shares during the last four decades. Groundnut production shares declined from 27% to 20% whereas groundnut oil export shares decreased from 55% to 24%. China, the world's leading producer, has increased its world shares by 4-fold from 10% to 38%. Argentina, the leading oil exporter, has doubled its world share from 12% to 23%. Senegal remains the lead groundnut oil exporter (19% of world exports) in West and Central Africa, followed by Nigeria (1.20 %). India is the lead exporter of groundnut cakes accounting for 65% of the world total, followed by a distant second Senegal with 10% and Argentina with 6%. Exports for confectionery groundnut increased by about 65% from 1979-81 to 2005-07 but most of this came from Asian countries accounting for about 47% of world exports. West Africa's contribution to confectionery groundnut exports fell by half from 43,956 MT to 27,495 MT from 1979-81 to 2005-07 respectively.

The European Union still remains the major importer of oil, cakes and confectionery groundnut. France is the lead oil importer accounting for 23% of world oil imports followed by Italy 17% and the USA, 14%. As for cakes, China is major importer of groundnut cakes accounting for 35% of world imports, followed by France 16% and Thailand, 11%. West and Central Africa are importing slightly more cakes. Whereas in 1961-65, there were no imports, this is increased to 2.54% of world imports.

While imports from other oil seeds such as soybean oils have quadrupled (4.85% to 16.31%) in WCA, palm oil significantly decreased from 48% to 28% of Africa's imports. The supply of palm oil has almost doubled while prices of these two oil seeds are about half groundnut oil price in the global market, making it less competitive. However, since 1984, groundnut production in WCA has been increasing by about 4.60%, annually mainly due to area expansion. Senegal and Nigeria remain among the largest world groundnut producers. Groundnut still remains a major source of employment, income and foreign exchange in many WCA countries. Therefore, there is a need to reassess market prospects and highlight opportunities for the region to regain its market share.

Competitiveness of WCA groundnut in the domestic, regional and international markets has been limited by the low productivity, aflatoxin regulations, and stricter grades and standards in addition to trade distortions caused by two largest developing countries, India and China. Relative prices of groundnut oils are higher in the international markets making these products less competitive compared to oil palms, cotton oil and other oil fruits. There are market niches for confectionery groundnut. Access to this market would require knowledge of market requirements, especially EU markets. To regain its competitiveness, groundnut productivity and production have to increase significantly, technologies to reduce aflatoxin contamination have to be promoted and grades and standards established.

Baseline surveys in project countries

Three baseline studies were carried out in program and non-program sites in Mali, Niger and Nigeria where the TL II project started its activities in 2007. These regions encompassed the Sahelian and Sudanian-savanna zones (Figure 4-1).

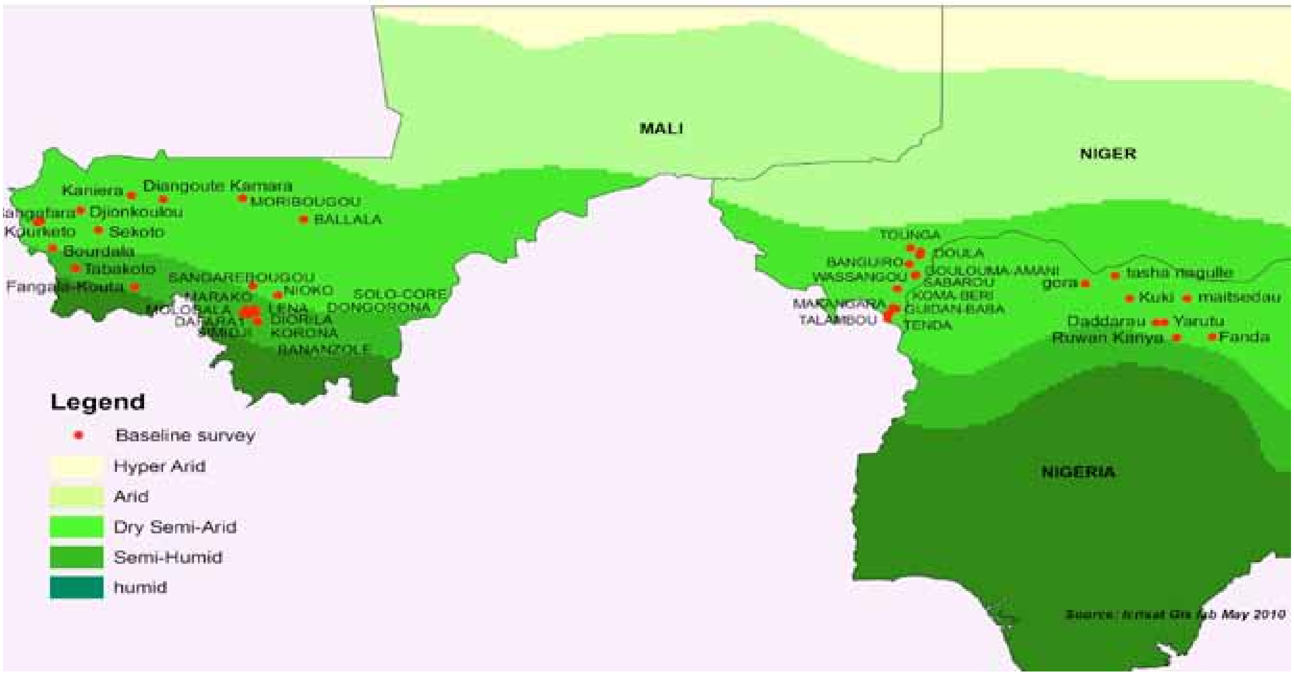


Figure 4-1: Selected villages for the baseline studies in Mali, Niger and Nigeria in 2007/08.

Data were collected using structured survey of households from November 2007 to February 2008 in the three countries. A purposive random sampling was used to select program sites. Next to every selected program site was a non-program site (a neighboring village) where the TL II program will not intervene. In each program site, 10 on-farm trial participants were selected from the population of participants and five non-trial participants were selected from the population of non-participants. In case the number of on-farm participants was less than 15 farmers, enumerators were asked to survey all on-farm trial participants with the remaining unchanged (Table 4-1).

Table 4-1: Distribution of HHs/UPAs surveyed by country and region in Mali, Niger and Nigeria

Country/Region or State	Site		Total
	Non-program site	Program site	
Mali			
Kayes	26	54	80
Koulikoro	28	58	86
Sub-total	*54*	*112*	*166*
Niger			
Dogondoutchi	62	68	130
Dosso	33	34	67
Gaya	49	112	151
Sub-total	*144*	*204*	*348*
Nigeria			
Jigawa	41	52	93
Kano	19	72	91
Katsina	40	54	94
Sub-total	*100*	*178*	*278*
TOTAL	**298**	**494**	**792**

Survey results indicate that groundnut is planted on about 36% of total cultivated area in Mali, 15% in Niger and 34% of cultivated area in Nigeria. Groundnut contributes to 64% of household cash revenues in Mali, 66% in Niger and 54% in Nigeria. It accounts for 28% of the total value of crop production in Mali, 31% in Niger and 23% in Nigeria. No statistical differences were found between program and non-program villages.

Groundnut market participation was very high in the surveyed sites. Many households sell groundnut in Mali and Niger and many purchase groundnuts in Nigeria. In Mali, 46% of households are net-sellers with no differences between program and non-program sites. In Niger, about 79% of households are net-sellers of groundnut with high rates in program versus non-program sites. In Nigeria, 72% of households are net-buyers of groundnut with significantly more households buying groundnut in program versus non-program sites. Households are net-sellers of cowpea for 8% in Mali, 24% in Niger and 7% in Nigeria. In the three countries, market participation in other crops is also important. In Mali, about 30% and 40% of households are buying rice and sorghum, respectively, with no differences between non-program and program sites. Pearl millet is thinly traded and farmers live as in autarky. In Niger, 39% and 42% of households are net-buyers of maize and pearl millet, respectively. In Nigeria, households are net-buyers of most of the agricultural products (Table 4-2).

Table 4-2: Proportion of households net-sellers, net-buyers and in autarky of agricultural products

Country / Product	Non-program sites		Program sites		Total	
	Net-buyer	Net-seller	Net-buyer	Net-seller	Net-buyer	Net-seller
Mali						
Cowpea	0.00	10.91	0.00	7.14	0.00	8.38
Fonio	0.00	0.000	0.00	0.89	0.00	0.60
Groundnut	5.45	43.64	10.71	46.43	8.98	45.51
Legume haulm	1.82	3.64	0.00	0.00	0.60	1.20
Maize	3.64	7.27	9.82	6.25	7.78	6.59
Pearl millet	0.00	1.82	6.25	3.57	4.19	2.99
Rice	29.09	3.64	30.36	0.89	29.94	1.80
Sorghum	34.55	14.55	42.86	6.25	40.12	8.98
Niger						
Cassava	4.03	0.67	7.14	0.95	5.85	0.84
Cowpea	2.01	32.21	6.19	18.10	4.46	23.96
Groundnut	1.34	71.81	0.00	84.76	0.56	79.39
Legume haulm	0.67	6.04	2.86	5.24	1.95	5.57
Maize	32.89	0.67	43.81	0.95	39.28	0.84
Pearl millet	50.34	7.38	35.71	6.67	41.78	6.96
Rice	2.68	0.00	2.86	0.00	2.79	0.00
Sorghum	14.77	2.01	5.24	0.48	9.19	1.11
Nigeria						
Cowpea	30.00	2.00	34.27	10.11	32.73	7.19
Groundnut	60.00	0.00	78.09	5.06	71.58	3.24
Maize	2.00	22.00	21.35	14.61	14.39	17.27
Pearl millet	15.00	10.00	30.90	6.18	25.18	7.55
Rice	4.00	4.00	11.80	20.22	8.99	14.39
Sesame	10.00	1.00	17.42	1.12	14.75	1.08
Sorghum	12.00	4.00	33.15	11.80	25.54	8.99
Sorrel	0.00	0.00	0.56	0.00	0.35	0.00
Soybean	2.00	1.00	7.30	2.25	5.40	1.80

Modern groundnut variety uptake in surveyed sites is estimated to be less than 5% except in the Dosso region in Niger, where this is estimated at 14% of groundnut area planted. Survey results showed that about 40% of groundnut area is planted with the variety 47-10 in Mali. In Niger 47% of area is planted with the variety 55-437 and in Nigeria the variety ex-Dakar i.e. 55-437 is planted on 41% of groundnut area. These are ruling varieties introduced at colonial times in the 1950s.

The area covered by modern varieties bred or adapted less than 30 years ago is small. In Mali, modern groundnut varieties (ICGV 86124, JL 24, ICGV 86015, ICG (FDRS)4 and ICG(FDRS) 10 and Fleur 11) Waliyartiga, introduced during the Groundnut Germplasm Project (GGP) in 1996 and promoted during the Groundnut Seed Project have not yet being largely taken up by farmers and are planted on about 3% of groundnut area. In Niger, in the Dosso region, several varieties were introduced during the GGP project and promoted during the GSP project including TS 32-1, RRB, etc have been adopted with 14% of area planted mostly with RRB.

In Nigeria, similar trends are observed. Improved varieties bred, adapted and introduced (SAMNUT 21, SAMNUT 22 and SAMNUT 23) during the last 30 years are adopted in less than 6% of groundnut area. No significant differences were found between program and non-program sites. The major constraints to using improved varieties have been reported by farmers to be the non-availability of seed for 83% in Mali, 60% in Niger and 56% in Nigeria. Lack of cash was cited as a major constraint in Niger and Nigeria. Low grain and haulm yields, lack of information on crop management, fitness in association, and undesirable color were also cited as the major constraints in Nigeria (Table 4-3).

Table 4-3: Constraints to adoption of modern varieties in Mali, Niger and Nigeria (2007/08)

Constraint	Mali		Niger		Nigeria	
	MV (6)	LV (91)	MV (5)	LV (166)	MV (18)	LV (131)
Non-availability of seed	83.33	27.47	60.00	57.83	55.56	30.53
Lack of money	0.00	6.59	20.00	4.82	5.56	6.11
Low yield	0.00	10.99	0.00	9.04	11.11	25.95
Low market value	0.00	1.10	0.00	0.00	0.00	6.11
Not good in association	0.00	1.10	0.00	0.00	5.56	2.29
Loss of variety due to drought	16.67	40.66	0.00	2.41	0.00	9.92
No information on management	0.00	2.20	0.00	0.00	5.56	3.82
Lack of labor	0.00	9.89	0.00	0.00	0.00	0.00
Late maturity	0.00	13.19	0.00	4.22	0.00	9.92
Susceptible to disease	0.00	0.00	0.00	0.00	0.00	9.92
Consumed	0.00	0.00	0.00	0.00	11.11	4.58
Low haulm yield	0.00	0.00	0.00	0.00	5.56	6.87
Undesirable color	0.00	0.00	0.00	0.00	5.56	4.58
Susceptible to insects	0.00	0.00	0.00	0.00	0.00	3.82
Seeds too small	0.00	0.00	0.00	0.00	0.00	3.82
Low content of oil	0.00	0.00	0.00	0.00	0.00	4.58
Other constraints	0.00	1.10	20.00	24.70	5.56	18.32

MV= Modern varieties, LV= Local varieties; values are percentages of response.

The use of other inputs (credit, inorganic and organic fertilizers) remains limited in surveyed areas. Groundnut production requires a larger amount of inputs such as seed, fertilizers and labor compared to cereal crops. Credit is required to access these required inputs. Survey results showed 46% of households have access to formal and informal sources of credit against 43% in Niger and 9% in Nigeria. The average contracted amount is about US$76 in Mali and $77 in Niger less than the amount needed to purchase one bag of fertilizers or seed to be planted on a hectare of groundnut. In Nigeria, however, this is estimated at US$500 (Table 4-4). The average interest rates on contracted loans are estimated at 24% in Mali, 11% in Niger and 15% in Nigeria. Most households contract loans for consumption purposes. However, in Mali, about 21% of the contracted amount is used for input purchase, about 30% in Niger and about 25% in Nigeria.

The use of inorganic fertilizers on groundnut fields is limited in Mali and Niger. In fact, fertilizers are applied to about 2.26% of groundnut plots grown by households in Mali and 16% in Niger. In Nigeria, inorganic fertilizers are used in about 61% of the groundnut plots. Likewise, the use of organic fertilizers is also limited. In Mali, about 14% of groundnut plots received organic fertilizers, 18% in Niger and 41% in Nigeria. The use of hired labor is relatively high.

In Niger, farmers use hired labor in 26% of the groundnut plots, 43% in Niger and 67% in Nigeria. Pesticides are widely used in the 3 countries but limited to seed treatment before planting. However, the intensities of inputs used are very small. On average, farmers use less than US$20 /ha of inputs in Mali, US$21 in Mali and US$123 in Nigeria.

Table 4-4: Amount requested, amount contracted, balance and credit duration (months)

Country / Variable	Type of village: Non-program site, Local currency	In $USD	Program site, Local currency	In $USD	Total sample, Local currency	In $USD
Mali (FCFA)	(28)		(49)		(77)	
Amount contracted/supplied	33 391	67	40 384	81	38 112	76
Amount requested	44 149	88	55 344	111	51 808	104
Loan balance	3 845	8	9 605	19	7 685	15
Interest amount	9 727	19	6 563	13	7 591	15
Loan duration (number of months)	9.54		10.85		10.32	
Niger (FCFA)	(34)		(117)		(151)	
Amount contracted/supplied	40 007	80	38 009	76	38 465	77
Amount requested	46 164	92	37 327	75	39 406	79
Loan balance	5 118	10	3 104	6	3 564	7
Interest amount	1 347	3	1 599	3	1 541	3
Loan duration (number of months)	5.01		4.50		4.61	
Nigeria (Naira)	(12)		(13)		(25)	
Amount contracted/supplied	49 583	354	88 538	632	69 840	499
Amount requested	58 750	420	215 000	1 536	140 000	1 000
Loan balance	9 000	64	82 385	588	47 160	337
Interest amount	2 125	15	10,423	74	6 440	46
Loan duration (number of months)	7.42		7.69		7.56	

In parentheses, the number of UPA/HHs surveyed;

Source: Baseline surveys in West Africa, ICRISAT/IER/IAR/INRAN, 2007/08

Gender: Groundnut is a woman's crop in some countries in West Africa

In Mali, 85% of private/individual plots belong to women and 35% in Niger. In Nigeria there is little participation of women in groundnut production activities. However, women are largely involved in local groundnut processing activities. There were no differences based on program and non-program villages.

Sources of seed

Households source planting seed from past harvests, village markets, other farmers, family and parents. In Mali, 80% of the farmers get seed from past harvests, 9% buy seed from the village markets, 6% from seed traders and about 8% from friends and parents. In Niger, 86% of the households draw their planting seed from past harvests, 7% from village markets, 4% from seed traders and 7% from friends and parents. In Nigeria, similar trends are observed. Seventy-one (71%) percent of households source their planting seed from past harvests, 21% from seed traders, 5% from extension services, and 10% from family and parents (Table 4-5). Households have little access to seed of the varieties released less than 20 years ago.

The major lessons drawn from this study include the following:

1. Groundnut is a major source of cash for smallholder farmers in WCA;
2. Groundnut is a major source of cash for women farmers;
3. Many households participate in the groundnut markets compared to other crops such as cereals;
4. Ruling varieties are still dominant;
5. The use of inputs such as fertilizers in groundnut is very limited; and
6. More than 86% of households still draw their seed from past harvests.

Table 4-5: Alternative sources of seed of varieties planted / adopted in Mali, Niger and Nigeria (2007/08)

Alternative source	Mali		Niger		Nigeria	
	MV (6)	LV (128)	MV (79)	LV (302)	MV (37)	LV (257)
On-farm trial	33.33	2.34	1.27	0.00	5.41	14.17
Other farmers	0.00	2.34	0.00	4.30	2.70	14.17
Family/parents	0.00	6.25	0.00	3.31	0.00	9.84
Own seeds	33.33	80.47	68.35	86.42	62.16	70.87
Seed traders	0.00	6.25	1.27	4.30	0.00	21.26
IER	33.33	0.78	NA	NA	NA	NA
IAR	NA	NA	NA	NA	24.32	0.39
ICRISAT	0.00	0.00	2.53	0.00	2.70	0.00
Village markets	0.00	8.59	3.80	6.95	0.00	0.00
Cooperatives	0.00	0.78	22.78	3.31	0.00	0.00
Extension services	0.00	0.00	0.00	0.66	5.41	5.12
Projects	0.00	0.00	0.00	0.00	0.00	0.79
NGOs	0.00	0.00	0.00	0.00	2.70	0.79
UNCC	0.00	0.00	0.00	1.66	0.00	0.00

a = Significant at 1%, b = Significant at 5%, c = Significant at 10%
In parentheses, the number of UPA/HHs surveyed, NA: not applicable

Sources: Baseline surveys in West Africa, ICRISAT/IER/IAR/INRAN, 2007/08

Uncovering farmers' preference for traits and varieties

Participatory varietal selection (PVS) trials revealed that farmers were able to discriminate most major plant and seed traits. In fact, plant and seed traits were found to be statistically associated with the varieties tested under the PVS. In Nigeria, for example, farmers found plant type, grain size, and resistance to diseases, color of the leaves, maturity, haulm yield, haulm quality, pod yield, grain color, foliar diseases, plant vigor, pod reticulation, pod filling, pod size, and number of pods as being largely associated with varieties tested. In Niger, plant type, resistance to diseases, color of the leaves, plant maturity, number of pods, p being pod size, pod yield, haulm quality, haulm yield and plant vigor as being strongly associated with varieties tested. In Mali, plant maturity, number of pods, pod size, pod filling, pod reticulation, pod beak, pod constriction, grain size, grain color, haulm quality, pod yield and taste were associated with the varieties (Table 4-6).

Table 4-6. Comparison of groundnut varieties for plant and seed traits rating by farmers in Mali, Niger and Nigeria

Trait of variety	χ^2 Values		
	Mali	Niger	Nigeria
Growth habit(0=Does not like, 1=Indifferent, 3=Like)	0.06	96.065***	78.7896***
Resistant to disease(0=Does not like, 1=Indifferent, 3=Like)	1.12	103.0814***	67.9819***
Color of leaves(0=Does not like, 1=Indifferent, 3=Like)	0.16	28.347***	102.2023***
Plant maturity(0=Does not like, 1=Indifferent, 3=Like)	4.84***	58.1466***	106.8041***
Number of pods per plant (0=Does not like, 1=Indifferent, 3=Like)	7.44***	70.8443***	176.0752***
Pod size (0=Does not like, 1=Indifferent, 3=Like)	10.23***	70.9605***	165.5034***
Pod filling (0=Does not like, 1=Indifferent, 3=Like)	6.04***	13.8605	68.1079***
Pod reticulation (0=Does not like, 1=Indifferent, 3=Like)	1.36		58.7847***
Pod beak (0=Does not like, 1=Indifferent, 3=Like)	8.69***	10.3235	NA
Pod constriction (0=Does not like, 1=Indifferent, 3=Like)	4.65***	11.0488	NA
Seed color (0=Does not like, 1=Indifferent, 3=Like)	0.42	5.6881	85.1387***
Seed size (0=Does not like, 1=Indifferent, 3=Like)	8.14***	34.9517***	110.6562***
Pod yield (0=Does not like, 1=Indifferent, 3=Like)	9.82***	33.6974***	143.3008***
Haulm quality (0=Does not like, 1=Indifferent, 3=Like)	7.92***	37.446***	70.9253***
Haulm yield (0=Does not like, 1=Indifferent, 3=Like)	11.93***	18.1532**	76.4963***
Pod reticulation (0=Does not like, 1=Indifferent, 3=Like)	NA	5.0006***	NA
Taste (0=Does not like, 1=Indifferent, 3=Like)	5.92***	NA	NA
Plant vigor (0=Does not like, 1=Indifferent, 3=Like)	NA	41.8187***	96.9593***
Flowering (0=Does not like, 1=Indifferent, 3=Like)	NA	NA	62.7933***

***significant at 1% probability, **significant at 5% probability, *significant at 10% probability;
NA = not applicable

Results showed that color of the leaves, maturity (short cycle), number of pods, pod size, constriction, pod yield, pod filling and taste were the important attributes explaining farmers ranking for varieties in Mali. In Niger, the color of the leaves, the number of pods, pod filling, pod beak, and pod yield were the most important traits sought by farmers. In Nigeria, plant vigor, plant maturity, plant type, number of pods, pod size, haulm yield and pod yield were the important traits (Table 4-7).

Table 4-7: Relative importance of variety attributes in Mali, Niger and Nigeria

Trait	Country/ Relative value		
	Mali	Niger	Nigeria
Plant maturity	9	NA	13
Number of pods	14	28	19
Size of pods	13	NA	NA
Pod constriction	7	NA	NA
Pod yield	8	23	15
Pod filling	34	9	NA
Taste	15	NA	NA
Disease resistance	NA	11	NA
Pod beak	NA	16	NA
Seed color	NA	13	NA
Plant vigor	NA	NA	20
Plant type	NA	NA	11
Pod size	NA	NA	7
Haulm quality	NA	NA	10
Haulm yield	NA	NA	5
Total	100	100	100

NA = not applicable; values are percentages of response

For some traits, varieties selected for the PVS were similar/identical not allowing farmers to differentiate between varieties based on those characteristics. Varieties selected by farmers can be site-specific and finally, attributes such as color of leaves, pod reticulation and pod beak tend to be neglected. Lessons learned include (1) a better choice of varieties for PVS with different traits, and (2) the need for targeting varieties to recommendation domains.

Early diffusion of groundnut varieties in the Dosso region, Niger

The contribution of groundnut to cash income of smallholder farmers has significantly increased in the surveyed areas. The total value of groundnut sales has increased. Groundnut contributes to 66% of household cash revenues in Niger in 2007/08 and has increased to 83% in Niger. No statistical differences were found between program and non-program villages.

Groundnut market participation has increased in the surveyed sites. In Niger, in 2007/08, it is estimated that about 79% of households are net-sellers of groundnut against 93% in 2009/10. In Niger, 39 and 42% of households are net-buyers of maize and pearl millet respectively.

The uptake of modern groundnut varieties in surveyed sites in the Dosso region in Niger has increased significantly from 14% of groundnut area planted in 2007/08. More than 95% of the area was covered with the variety RRB. Survey results showed that 47% of area was planted with the variety 55-437. Several varieties were introduced during the GGP project and promoted during the GSP project including TS 32-1, RRB, etc have been adopted with 14% of area planted mostly with RRB. The major constraints to using improved varieties have been reported by farmers to be the non-availability of seed for 60%. Lack of cash was cited as a major constraint.

In 2009/10, it is estimated that 64% of farmers have adopted at least one improved variety of which more 90% was the variety RRB i.e. 56%. The proportion of area covered with improved varieties is estimated to about 49% with RRB alone accounting for 39% and other varieties such as Fleur 11, J11, ICG 9346 and TS 32-1 accounting for about 10%. However, the area covered by 55-437 has decreased to 32%.

The use of other inputs (credit, inorganic and organic fertilizers) has not improved in surveyed areas. The use of inputs on groundnut fields remained limited. But access to seed has significantly improved as a result of building seed supply systems in project sites.

Access to major productive resources is still limited for women. In surveyed sites, female farmers still plant less groundnut area than men 0.77 ha against 0.94 ha for ex. Farmers have less access to improved seed. In particular, female farmers have almost no access to organic fertilizers. About 2.5% of female farmers surveyed used manure in their fields against 22% for men.

Variety Development

Summary

This report highlights the progress made during the last four years of project implementation in WCA. The project is being implemented in Mali, Niger and Nigeria. The major activities focused on farmer participatory variety selection (PVS), crop improvement and capacity building. Significant achievements have been made in all the areas.

Starting from the 2007/2008 cropping season, PVS was carried out in 18 locations (six each in Mali, Niger and Nigeria) using a mother-baby trial approach. These trials were used to assess farmers' preferences for plant and seed traits of selected varieties. Preference for traits were revealed using structured surveys administered to a panel of farmers in each pilot site. Based on the PVS trials the national program in Niger released four varieties (RRB, ICG 9346, J11, and Fleur 11) in 2010. Similarly, five varieties, including ICGV 86015 and ICGV 86124 from the PVS have been submitted to the national registration committee for inclusion in the variety catalog in 2011. Three short-duration rosette resistant varieties (ICIAT 19 BT, ICIAT 6A and ICIAR 7B were included in national demonstrations/trials and ICIAR 19 BT was released as SAMNUT 24 in Dec. 2011. Between 400 and 500 farmers directly or indirectly participated in the trials in each participating country. Participation of technology transfer/extension institutions and farmers organizations facilitated the access of farmers to new varieties, management practices and information. In Niger and Mali groundnut farmers especially women are keen to adopt new improved varieties.

Various pathways were used to share information, methodologies and outputs among stakeholders. This was achieved through hosting workshops, annual planning sessions, progress reports, user-friendly brochures and flyers; on-farm and on-station field days, farmer-to-farmer visits; radio and television coverage. Over 5000 farmers are aware of new improved varieties.

Significant achievements were made in variety development. ICRISAT supplied close to 1000 trait-specific advanced breeding lines (resistance to aflatoxin contamination, foliar diseases, rosette, early – and medium maturing, confectionery types and tolerant to drought including 45 segregating populations were made available to the national programs. Phenotyping facilities (laboratory and field) in Mali, Niger and Nigeria were rehabilitated and hybridization initiated in Niger and Nigeria.

Four scientists from Nigeria, two from Mali, and one from Niger benefitted from a 10-day training workshop in breeding methodologies. A technical guide consisting of 10 training modules was compiled. Ms Idi Mariam of INRAN Niger completed her MSc program in May 2010 and successfully defended her. Mr. Mamary Traore of IER Mali started his MSc research at ICRISAT in July 2011 and is expected to graduate in December at University of Ouagadougou. Simplified brochures on varieties grown in Mali and crop management were prepared in French for eventual translation into the local language- Bambara.

Introduction

Groundnut productivity is limited by a number of abiotic and biotic stresses (such as drought, foliar diseases, rosette, and aflatoxin contamination) in the semi-arid zones of Wes Africa. The gap between potential and realized yield is large in subsistence farming. To improve productivity at the farm level and bridge the yield gap requires varieties that have farmer- and market-preferred traits, including those that enhance and stabilize productivity, increase profitability of the crop and thereby the income of smallholder groundnut farmers. This project builds on the achievements made by ICRISAT and partners in groundnut improvement in the last 30 years. Only one rain-fed crop season starting in June and ending in October is possible in the major groundnut areas in the three countries. The project's variety development strategy takes advantage of existing improved germplasm in the short term, through participatory variety selection. At the same time, new segregating populations are developed and selected for tolerance/resistance to the biotic and abiotic constraints. This is complimented by a seed delivery strategy that will emphasize decentralized, pro-poor seed production and delivery systems.

Targets

The major targets are as follows:

- 2-3 farmer- and market-preferred groundnut varieties identified for cultivation in focal regions in each partner country;
- 2-3 varieties identified entered in formal testing system in each country, if required by the national seed policy for official release;
- At least 5000 farmers made aware of the improved groundnut varieties in each country;
- Nucleus and Breeder seed of farmer-preferred varieties as required produced each year to support Seed System activities (Objective 8) in focal regions in each partner country;
- Each year 80-100 new breeding lines with farmer- and market-preferred traits made available by ICRISAT to NARS for local evaluation;
- Breeding activities (and associated phenotyping facilities) initiated in at least one research station in the focal region in each country;
- Two students trained at MSc level in conventional and modern breeding techniques and technicians trained hands-on in groundnut breeding and integrated crop management;
- One efficient groundnut improvement program with appropriate phenotyping facilities (field and laboratory screening) for drought and foliar diseases established in each partner country; and
- Farmer-friendly literature in vernacular languages (Bambara, Hausa) on improved varieties and integrated crop management technologies available.

Methodology

Participatory variety selection (PVS)

PVS using the mother and baby trial approach has been used to increase farmers' exposure to new groundnut varieties and assess farmers' trait preferences for varieties. The demand for varieties by farmers and the processing industry is a result of plant, seed and other desirable traits that are embodied in the variety. Knowledge of the range of plant, seed and processing traits is valuable for crop improvement programs and good market signals for processors. The demand for improved groundnut varieties will increase if varieties are designed to include producer- and consumer-preferred traits. Therefore, improving the performance of varieties accounting for all significant traits will contribute to the productivity and profitability of groundnut production in West Africa. The objective of this activity is therefore to identify farmers-preferred traits and varieties through PVS.

A PVS evaluation was launched in pilot sites in Mali, Niger and Nigeria in the 2008 crop season. The trial sites span a range of socio-economic and demographic setting and are representative of the agro-ecologies suitable for groundnut production in drought -prone zones of West Africa. The varieties tested in each country are listed in Table 4-8.

Table 4-8: Varieties included in the PVS trials in 2008/09 season

Variety name	Characteristics	Remarks
Mali		
ICGV 86024	Tolerant to drought	Pre-release
ICGV 86124	Tolerant to drought	Pre-release
ICGV 86015	Tolerant to drought	Pre-release
ICGV 97188	Tolerant to drought	Pre release
ICG (FDRS 4)	Foliar disease resistant	Released
ICG 7878 (W tiga)	Foliar disease resistant	Released
Fleur 11	Early maturing	Released
JL24	Early maturing	Released
Niger		
ICG 9346	Early, drought tolerant	Pre-release
RRB	Early, drought tolerant	Pre-release
J 11	Early and tolerant to aflatoxin contamination	Pre-release
TS32-1	Ruling	Released
Fleur 11	Early maturity, bold seed	Pre-release
55-437	Ruling and tolerant to aflatoxin	Released
Nigeria		
ICIAR 6A	Extra early, rosette resistant	Pre-release
ICIAR 7B	Extra early, resistant to rosette	Pre-release
ICIAR 19BT	Extra early, resistant to rosette	Pre-release
SAMNUT 21	Medium- duration dual- purpose	Released
SAMNUT 22	Medium- duration dual purpose	Released
SAMNUT 23	Early maturity, resistant to rosette	Released

Locations

Mali

Groundnut production is concentrated in the West, south, part of the center covering the regions of Koulikoro, Kayes Sikasso and Segou. These regions account for 97% of area and 95% of groundnut production in Mali. Rainfall ranges from 400-800 mm per years**.** Farmers still grow the old varieties including 47-10 and 28-206 introduced more than half a century ago. However, new varieties have been released in the last decade but have not completely replaced these old ones. The project pilot sites are located in the regions of Kayes and Koulikoro. Kayes is the major growing region accounting for 33% of the area and 35% of groundnut production in Mali. Koulikoro on the other hand accounts for 21% of groundnut area and 24% of groundnut production (DNSI, 1996/97**).** Three pilot sites were identified in each region**: T**he trials were Diankoute Camara, Sadiola and Dialafra in Kayes; Marako, Diorila and Faladie in Koulikoro. In each of the pilot sites a mother trial was set up in a randomized complete block design of five varieties with five replications (4 new varieties and a local check). The plot size for each variety was 10 x 10 m per replication.

The mother trials were implemented collectively by farmers selected by the village chief or farmers' associations. Baby trials were conducted by 20 individual farmers in the same villages. Farmers grew 2-3 new varieties along with their local variety under traditional management practices. Other than seed no other inputs were provided. Replication was across farmers, either in the same village or across villages. The PVS trials were repeated in the 2009/10 season in the same villages with larger plots. The varieties were sown in plots of 20 x 50 m or 0.1 ha in each of the six villages in Mali. For the baby trials out of 120 farmers expected 108 were implemented. The number of farmers involved in the trials is presented in Table 4-9. The interest of Plan Mali (an International NGO) to include groundnut production by the women groups in their areas of intervention has facilitated the extension of mother trials in five new villages in the Koulikoro region in 2010/11 cropping seasons. The trials were managed by 25 women in each village. The plot sizes were 0.1 ha per variety.

Niger

The pilot sites are located in the Dosso region. Soils are mainly sandy accounting for two thirds of the region, with clayey soils in less than 10% of the region. The main rainfed crops are millet, sorghum, cowpea and groundnut. The experimental sites were Doula, Guida Gaba, KomaBeri, Tanda, Tounga and Wassangou. The most popular variety grown throughout Niger is 55-437 .The Mother trials were managed by a group of 36 farmers in each village. Satellite baby trials were also set up in the same villages. Overall, 167 men and 25 women were involved.

Nigeria

The pilot sites are located in the states of Jigawa, Kano and Kastina that account for more than 50% of the total groundnut production in Nigeria. These states span the Sudan-sahelian ecologies prone to drought; where millet, sorghum, cotton, groundnut, cowpea and vegetables are major crops. The rainfall in these states varies between 600 and 900 mm. Groundnut rosette is a major biotic constraint. The most widely grown varieties are 55-437, RRB, and RMP 12. However, new varieties released in the last decade are finding their way into the farmers' fields. The pilot sites, names of farmers conducting mother and baby trial are presented in Table 4-10.

Table 4-9: Number of farmers involved in the baby and mother trials in Mali

Location	Year			
	2008	2009	2010	Total
Marako	21	21	21	63
Diorila	21	21	21	63
Faladié	21	21	41	103
Diancounté Camara	21	21	17	59
Sadiola	21	101	85	207
Dialafra	21	21	21	63
Total	126	206	240	558

Table 4-10: Locations and contact farmers in the pilot sites in Nigeria

Location/Contact Farmers		
Jigawa State		
No.	Village I: Worno (Gumel L.G.A)	Village II: Zaburan (Birnin – Kudu L.G.A)
	Baby Trial	Baby Trial
1	Mall Yakubu	Alhaji Saleh Mohammed
2	Isaleh Magaji Hussaini	Abdullahi Shuaibu
3	Nuhu Dogo	Mohammed Madawaki
4	Garba Zubairu	Abdul Alhassan
5	Abdullahi Yahaya	Ubali Hussaini
6	Alhaji Danbaba	Haruna Idi
7	Jamillu A. Shitu	Usman Hodi
8	Bako Garba	Alhassan Kuri
9	Maigari Ya'U	Ado Musa
10	Malasan Dan – Garba	Awal Mohammed
	Mother Trial	Mother Trial
11	Muhammed Mujitaba	Alhaji Musa Tella
12	Ali Hussaini	Alhaji Yunusa Wada
Katsina State		
No.	Village I Kuki (Charanchi L.G.A)	Village II Tashar Nagulle (Batsari L.G.A)
	Baby Trial	Baby Trial
1	Mall. Madu	Mai Unguw Umaru
2	Alhaji Mansur Bala	Malam Sahalu
3	Alh. Sunusi	Mali Basiru
4	Mall. Manya	Alhaji Abu Kafinta
5	Abubakar Decoration	Halilu Nabawa
6	Alh. Ibrahim	Idriss Lawal
7	Mall. Jibo Police	Abdullahi Nuhu
8	Garba Officer	Mai Unguwa
9	Bashir Amadu	Alhaji Ali
10	Ibrahim Lawal	Lawal Yandaka
	Mother Trial	Mother Trial
11	Alh. Maiunguwa Sa'adu.	Samaila Abdullahi
12	Danlami Abdul – Rasheed.	Abubakar Yusuf
Kano State		
No.	Village I: Rumrum/Ruwankanya (Rano L.G.A)	Village II: Yar – Rurtu (Dawakin Tofa L.G.A)
	Baby Trial	Baby Trial
1	Dubai Dan – Sidi	Alhaji Abu Mohammed
2	Gambo Mohammed	Alhaji Audu Ali
3	Alhaji Ibrahim Dan Barebari.	Alhaji Rabiu Abdul (Bunsen Burner)
4	Mai Ungwa Umaru	Muntari Abdul
5	Yakubu Mohammed Dan Kaduna	Musa Kani
6	Alhaji Umaru	Alhaji Dahiru
7	Isiya Salisu	Shehu Abdul
8	Umaru Abdulsalam	Sale Bala
9	Bako Monitor	Abudwahab
10	Garba Mai Shayi	Dantsoho Sa'adu
	Mother Trial	Mother Trial
11	Allaramma	Alhaji Mohammed yar' Rutu
12	Alhaji Salisu Uban – Ado	Alhaji Yahaya

Nucleus and breeder seed production

The nucleus and breeder seed production was supported in the NARS to facilitate entry of new varieties in the seed chain.

Increasing farmers' awareness of new varieties

Various pathways including workshops, field days, farmer friendly literature, radio and television, were used to share information, methodologies and outputs among the various stakeholders.

Achievements

PVS

Mali

ICGV 86124 and ICGV 86015 were the highest yielding varieties in the pilot sites in the Kayes region compared to the local checks (Table 4-11). In the Koulikoro region, the average yield of ICGV86124 was 1692 kg per ha, compared to 1478 kg per ha for the local check in the mother trials. The pod yield of ICGV 86015 averaged 1721 kg/ ha or 16% above the check. In the Kayes region, ICGV 86124 averaged 1873 kg per ha, compared to 965 kg per ha for the check. On the other hand, ICGV 86015 averaged 2055 Kg/ha more than double the check variety. The superiority of these two varieties was corroborated by yields from 120 individual farmers' fields (baby trials) in the two regions. These two varieties have been recommended for release. ICGV86124 has been renamed YIRIWA tiga and Nietag-tiga for ICGV 86015. The two varieties are early maturing (100 days) and tolerant to drought.

Niger

Overall, three varieties - RRB, ICG 9346, and J11 stood out to be the preferred by farmers because of higher pod yield, early maturity, higher number of pod per plant, and good pod filling (Ndjeunga et al, 2010. Thirty rural women processors performed sensory tests which indicated that Fleur 11, RRB, ICG 9346, J 11 and TS32-1 were superior to 55-437 in terms of oil color and fluidity. The quality of the groundnut paste was also better. The national program registered RRB, ICG 9636, JII and Fleur 11 in the National Variety Catalog in 2010.

Nigeria

Overall 37 baby and 12 mother trials were established in the project sites 2008/09 seasons. In the 2010 season selected varieties were put into large demonstrations in the pilot states and two others (Bauchi and Kaduna) to enhance awareness of farmers' about the new varieties and release. Preference tests revealed that early maturity, high pod and fodder yield, resistance to foliar diseases and tolerance to drought were the preferred traits. However, preferences often differed among regions and sites, reflecting differences in agro-ecological zones.

Production of nucleus and breeder seed of farmer-preferred varieties

The availability of nucleus and breeder seed is critical to ensure that varieties that meet the needs of the farmers and market requirements are accessible to those who want to grow the new varieties. During the 2007 /08 crop season ICRISAT in Mali assembled 99 elite lines and produced nucleus and Breeder Seed that provided the seed stock for the PVS trials in the project pilot sites. In subsequent years, Breeder Seed and some times, Foundation Seed was produced to support the seed systems objective as well as sharing the germplasm with NARS.

Overall, the production of breeder seed by the NARS partners remains very low and inconsistence (Annex). This is partly due to reliance on rainfed conditions in drought prone-areas resulting in low yield in case of drought stress. This calls for a careful choice of sites where seed should be produced or have functional irrigation facilities to assure seed quality and supply.

Table 4-11: Mean pod yield (kg per ha) of PVS varieties averaged over 2008 and 2009 in Mali.

Variety	Koulikoro Region								
	Marako			Diorila			Faladié		
	2008	*2009*	*Mean*	*2008*	*2009*	*Mean*	*2008*	*2009*	*Mean*
ICGV 86015	1790	1600	1695	1428	1600	1514	2460	1450	1955
ICGV 86124	1662	1450	1556	1460	1750	1605	2310	1520	1915
JL 24	1842	1800	1821	1320	1650	1485	2320	1256	1788
Fleur 11	1418	1450	1432	1520	1780	1650	1686	1668	1677
Local Check	1428	1440	1434	1756	1440	1598	1920	1198	1559
Mean	**1628**	**1548**	**1588**	**1497**	**1644**	**1570**	**2139**	**1418**	**1779**

Variety	Kayes Region											
	Diankounté Camara				Sadiola				Dialafra			
	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean
Fleur 11	690	1450	1480	1206	1520	3000	2800	2440	1100	749	1650	1166
JL 24	550	990	1450	997	1700	2800	2800	2433	1100	646	1015	920
ICGV 86124	700	1600	1675	1325	1900	3800	3500	3067	1220	611	1850	1227
ICGV 86015	550	1700	1380	*1210*	2200	3600	3150	2983	1180	589	1750	1173
Check	760	890	950	867	1610	1100	1100	1270	760	400	1120	760
Mean	**650**	**1336**	**1387**	**1224**	**1802**	**2860**	**2670**	**2444**	**1072**	**660**	**1477**	**1070**

Enhancing farmers' awareness of improved varieties

Among the major constraints limiting the uptake of improved groundnut varieties is the lack of awareness by the farmers about them. Paramount among the project goals is the information flow to beneficiaries. Various pathways were used to share information, methodologies and outputs among the stakeholders. This was achieved through hosting workshops, annual planning sessions, progress reports, user-friendly brochures and flyers; on-farm and on station fields days, farmer-to-farmer visits; radio and television coverage.

Stakeholder meetings

ICRISAT organized in-country project inception workshops in 2007 in Mali, Niger and Nigeria. Participants included representatives of the national agricultural research and extension systems (NARES), ICRISAT, farmers and farmers' organizations, groundnut traders and processors, private seed companies and journalists. In Mali, 47 participants (41 men and 6 women) attended the workshop. In Niger, 37 (25 men and 12 women) and in Nigeria, 45 (all men) attended. Similar numbers participated in subsequent annual in-country meetings. On-farm visits were carried out by project staff from the NARES and ICRISAT on a regular basis to monitor progress, advise, train farmers and other stakeholders in the best practices to enhance groundnut productivity.

In the 2008 season, at least two field days were held in each project site. Both women and men attended these field days. On average 30-200 persons participated in these open field days each year. At one such field day in Nigeria, high ranking officials of the government of Kano state attended. The event was well covered on state television. At ICRISAT-Bamako, three open house field days targeting a range of clientele (farmers, researchers, development partners and the private sector) were organized at the ICRISAT research station in Mali. Overall over 600 persons attended these field days and were aired on the local radio and television. Through such mechanisms, requests for seed of new varieties are on the increase.

In 2009, annual review and planning meetings were organized in each partner country to discuss progress of the project, on-farm and on-station trial designs and implementation. On-farm visits and field days are being organized in the current cropping season.

During 2010 cropping season, ICRISAT-Mali organized a field day for stakeholders on 28 October 2010 at the Samanko Research Station. A total of 200 visitors (69 women and 131 men) including farmers from the various locations where PVS trials were conducted, representatives of farmers organizations, NGOs and development partners were exposed to 24 new trait-specific {(tolerant/resistant to : foliar diseases, aflatoxin contamination, groundnut rosette, drought) and confectionery} varieties sown in demonstration plots. This visit was also aired on local television and radio, thus reaching a wider audience.

IER-Mali organized an on-farm field day at Sadiola and 94 farmers participated. An on-station field day at Same, chaired by the regional governor attracted 150 participants. During all these events the participants were familiarized with new varieties and other productivity enhancing technologies. A documentary film of 20 minutes was prepared in Niger based on the activities in the pilot sites to raise stakeholders' awareness of newly released varieties. This is expected to reach a wider audience.

In Nigeria, six field days/farmer meetings were held at the eight demonstration trial sites and one at Samaru before harvest. A total of 932 farmers, all men, participated in the field days. The number of participants ranged from 87 to 264 per location.

Variety development

NARS in WCA lack human resources and infrastructure to execute an efficient groundnut breeding program. These weaknesses have limited the flow of improved varieties and farmers continue to grow old varieties that were developed or introduced more than half a century ago. One of the objectives of this project is to enhance capacity of some of the NARS to breed groundnuts with multiple attributes. To this effect ICRISAT has supplied more than 600 diverse genetic materials from which to select adapted farmer-and market preferred varieties. Staff to manage the breeding programs was offered hands-on training in breeding principles and how to manage a breeding program including priority skills such as hybridization, data capture and analysis. The new materials have stimulated rejuvenated breeding activities of the participating NARS who have initiated national variety trials in the target ecologies.

Variety trials

Mali

In 2008 IER received 77 traits specific advanced breeding lines (15 drought tolerant, 15 medium maturity, 15 early maturing and 32 rosette resistant). These were evaluated in. replicated variety trials (4 row plots of 4 m long) along with local checks. In addition 288 F_7-F_8 lines with various attributes (resistant to rosette disease and the vector aphid, resistant to early leaf spots and earliness and limited fresh seed dormancy) were supplied as observation nurseries. These were successfully conducted at the IER research station in Kayes. In 2009 IER received 19 new advanced breeding lines resistant to aflatoxin contamination for on-station testing.

During the 2010 and 2011 cropping seasons, a series of advanced trials were conducted using the material selected from the observation nurseries and multi-locations on-farm trials involving promising lines from the advance trials. Overall, IER has conducted 22 observation nurseries, 11 preliminary trials, 14 advanced yield trials and 5 on-farm trials.

Niger

INRAN-Niger, received 45 advanced breeding (15 drought tolerant, 15 medium and 15 early maturing rosette resistant) lines for replicated trials in 2008. The plot sizes and designs were similar to those in Mali. In 2009 ICRISAT-Mali, further supplied 397 breeding lines grouped into various trait-specific nurseries. These were grown at Maradi Research Station. Forty lines from the germplasm supplied in 2008 and 2009 were evaluated at three locations (Tarna, Magaria and Bengou) in 2010. The yield of selected lines ranged from 14 to 42% over the checks. Among these were ICGV–SM 99502, ICGV-SM 99 510 and ICGV-SM

99511 (Table 4-12). Most important these varieties are early to medium maturing (110-115 days sowing to maturity) and are resistant to the groundnut rosette disease that is prevalent in these locations.

Table 4-12: Mean performance (kg per ha) of new selected lines at three locations in Niger

Variety/Line	Tarna			Magaria	Bengou	Mean	Yield advantage over check (%)
	2008	2009	2010	2010	2010		
ICGV 86063	363	965	400	321	1458	701	15
ICGV-SM 99502	758	960	718	708	1042	837	37
ICGV-SM 99510	907	707	691	375	1668	870	42
ICGV-SM 99511	1592	529	241	333	792	697	14
ICGV 9346 (check)	186	986	169	458	1250	610	100

Nigeria

In 2008, IAR received $F_{8-}F_{12}$ 74 rosette disease resistant lines as observation nurseries (2 rows, 4 m long, non-replicated) grouped into early, medium and late maturing).. Additionally, five breeding nurseries consisting of 104 progenies derived from F6/F7 populations with enhanced resistance to the groundnut rosette diseases and the vector aphid were supplied for local evaluation and selection of promising material. From these initial nurseries, selected lines were evaluated on station in 2009 to increase seed for multi-location trials in 2010 crop season. One hundred and two breeding lines were evaluated in 22 multi-location trials in 7 states (Table 4-13).

Table 4-13: Number of trait-specific entries entered into national multi-location variety trials in 2010

Trait	Number of entries	Locations	State
Confectionary	12	Bauchi Bebeji Zaria	Bauchi Kano Kaduna
Rosette Resistant Lines Trial	16	Bauchi Yauri Malam-Madori Zaria	Bauchi Kebbi Jigawa Kaduna
Rosette + aphid resistant Lines Trial	21	Azare Fakai Zaria	Bauchi Kebbi Kaduna
Rosette + fresh seed dormancy Lines Trials	14	Samaru-Kataf Arewa Zaria	Kaduna Kebbi Kaduna
Advanced rosette resistant Lines Trials	18	Birnin- Kudu Danbata Matazu Maigana Zaria	Jigawa Kano Katsina Kaduna Kaduna
Rosette resistant lines	21	Maiyama Wanke Zango Zaria	Kebbi Zamfara Katsina Kaduna

ICRISAT: To maintain a flow of new breeding lines, a series of trait-specific preliminary and advanced performance trials were also conducted by ICRISAT scientists in Mali and Niger. A list of these trials is presented in Table 4-14.

Table 4-14 Trait-specific breeding nurseries conducted at ICRISAT locations in Mali and Niger, 2008-2010

Trait	Number of entries	Number of replications
2008		
Advanced Short duration trial	16	3
Advanced drought tolerant trial	16	3
Advanced medium maturity	16	3
Advanced aflatoxin trial	16	3
Advanced foliar disease resistant trial	16	3
Preliminary foliar disease resistant trial	49	3
2009		
Advanced Drought tolerant	16	3
Advanced Medium maturity	16	3
Advanced Early maturity	16	3
Advanced Aflatoxin tolerant	16	3
Preliminary rosette + aphid resistance	49	3
Preliminary Aphid resistant	54	3
Preliminary foliar disease + aphids	81	3
Preliminary Rosette + seed dormancy	49	3
Preliminary rosette resistance	201	2
2010		
Advanced Aphid resistant	36	3
Advanced Aphid resistant + rosette	36	3
Advanced rosette + seed dormancy	36	3
Advanced Rosette resistant	49	3
Advanced foliar disease resistance + aphids	63	3
Foliar disease resistant	16	3
Advanced Aflatoxin contamination	64	3

Aflatoxin management

Aflatoxin contamination of groundnut has gained global significance due to the deleterious effects on human and animal health. It also affects the competitiveness of groundnut in the international market. Studies have shown that the use of tolerant varieties in combination with agronomic practices can minimize aflatoxin risks in groundnut products. The objective is to identify productive varieties that are tolerant.

In the 2008 crop season, 15 breeding lines along with the local controls were evaluated in replicated trials for yield and aflatoxin contamination at ICRISAT in Mali. Pod yields varied between 523 kg to 2794 kg per ha (Table 4-15). The highest yielding varieties were ICGV 93305 (2.8 MT per ha), ICGV 94379 (2.7 MT per ha) and recorded the aflatoxin content comparable to the resistant check.

In 2010, 61advanced breeding lines selected for tolerance to aflatoxin contamination were evaluated in replicated trials in Mali and Niger. Additionally, 32 inter-specific derivatives were also evaluated for yield potential as well as aflatoxin contamination at Samanko. The results in all locations (stations and farmers' fields) showed that 4 groundnuts advanced breeding lines ICGV 91324 (0.5 ppb), ICGV 91283 (0.7 ppb), ICGV 91317 (0.7 ppb) and ICGV 93305 (0.9 ppb) were more resistant than the resistant check 55-437 (1.3 ppb). Also these 4 lines were high-yielding (2 MT per ha) breeding lines.

Among the interspecific derivatives 19 were resistant to aflatoxin contamination in both locations (Mali and Niger) with aflatoxin contents varying from 0.2 ppb to 2.9 ppb. Among these 19, three interspecific derivatives; 4366-4 (0.15 ppb), 4897-17 (0.15 ppb) and 4655-2 (0.3 ppb) were more resistant than the resistant check 55-437 (0.6 ppb).

The high yielding lines that are resistant aflatoxin contamination will play a major role in the integrated management of the problem. The next step is to make them available to farmers through PVS.

Table 4-15: Evaluation of groundnut genotypes for their resistance to aflatoxin contamination, Samanko, Mali, 2008

Genotype	Pod yield (MT per ha)	Aflatoxin content (ppb)
ICGV 94379	2686	1.36
ICGV 94434	2489	37.18
ICGV 91278	1801	5.11
ICGV 91328	2113	8.17
ICGV 91341	2167	82.37
ICGV 93305	2794	0.89
ICGV 91317	2081	2.47
ICGV 91279	2149	0.97
ICGV 91284	1769	1.69
ICGV 92302	1674	2.01
ICGV 91315	1987	1.80
ICGV 91324	2087	1.44
ICGV 93328	1132	8.76
ICGV 91283	523	1.80
ICGV 89104	2039	2.12
55-437 (Resistant check)	1690	1.23
JL 24 (susceptible check)	1917	899.12
SEM (±)	156	4.67
CV (%)	14	23

RCBD design with 3 replications; plot size = 12 m^2

New breeding populations

Generation advance

Sixty-nine F_3 and 28 F_5 bulk populations were grown at ICRISAT-Mali for generation advance. Over 600 individual plant selections were made based on pod load and other desirable agronomic characteristics. The seed of each single plant was increased in the 2009 off-season under irrigation. These were evaluated for agronomic traits in the main crop season.

Generation of new breeding populations

Fifty three crosses (30 for foliar diseases resistance, 12 for productivity, 10 for aflatoxin contamination tolerance, and 1 for limited fresh seed dormancy) were made between September and December 2008 to generate populations with the desired attributes. Parental lines used included the most popular varieties in West Africa and high yielding foliar diseases resistant lines ICG # 7878, 7, 6222, 4440, and ICG (FDRS) 4. In the productivity crosses, the new parental lines were ICGV 00350 and ICGV 9114. For aflatoxin, the sources of resistance/tolerance are 55-437 and J11.

In the 2009 crop season, the 53 F1 of the crosses made in the previous season were sown at ICRISAT-Mali to produce the F2. Fifteen new crosses involving farmers- and market-preferred traits as parents were completed to generate new populations with enhanced productivity.

In 2010, 59 $F_{2:3}$ populations involving the most popular varieties in West Africa and sources of resistance to foliar diseases, aflatoxin contamination and rosette were advanced to the next generation. Population size varied from 200 to 800 plants per population. Single plants and bulks were selected. Five of these populations involving a stable source of ELS resistance (ICG 7878) crossed with the most popular varieties (55-437, 47-10, ICGV 86124 and Fleur 11) were advanced through single seed descent (SSD) during the post-rainy season (November-April) to produce $F_{4:5}$ RILS for phenotyping in 2011 crop season (June-October). The stage is now set for developing populations to validate the QTLs for Marker assisted breeding and this shows a clear linkage between TL I and TL II projects.

A total of 40 new three-way crosses involving farmer-preferred varieties and sources of resistance to early leaf spot (ICG 7878) and rosette (ICIAR 19 BT) were made and the F1 grown.

Breeding and associated phenotype activities

Strengthening breeding and phenotyping infrastructure

Hybridization and phenotyping facilities for drought, foliar diseases and groundnut rosette diseases were assessed for adequacy/improvements as well as staff to manage these facilities in Mali, Niger and Nigeria. Overall, these facilities were either lacking or in disuse. In Mali the phenotyping facilities needed are for drought and foliar disease screening, in Niger mainly drought and in Nigeria, phenotyping facility for groundnut rosette disease and raising the aphid vector needed rehabilitation.

Mali: A half-hectare plot at Same research station of IER was fenced to protect the nurseries from animal damage.

Niger: The focus was on the rehabilitation of the irrigation system at Maradi, to enable phenotyping for drought stress, generation advance and assurance of production of breeder seed. This involved purchase of 2 immersble water pumps and regeneration of wells to ensure constant water availability and an 18 KVA generator to ensure electric power supply. The pathology screen house was also rehabilitated to ensure phenotyping for diseases and maintaining inoculums for target diseases and insect pests. Other infrastructure improvements included: renovation of the seed store, purchase of laboratory equipment such as electronic balances, refrigerator, plastic sheeting, groundnut sheller, a motorcycle, a digital camera and office furniture.

Nigeria: The renovation of a screen house for phenotyping purposes was completed. The genotyping facility was enhanced by the purchase of an Alpha merger mini analysis system, digital thermal printer, alpha InfoTech computer and Thermal paper high gloss.

At the beginning of the project no hybridization activity was conducted at any of the participating NARS. After the training of technicians in managing crossing blocks, and the rehabilitated facilities, hybridization has been initiated at INRAN and IAR

Upgrade skills and capacity of NARS

Degree related training

Ms. Nana Mariama Idi Garba of INRAN, Niger, completed her MSc program in breeding at the University of Niamey in 2010. Mr. Mamary Traore, IER-Mali, initially registered at the University of Bamako, had registered at the University of Ouagadougou, Burkina Faso, as a result of indefinite strike by professors at the University of Bamako. This resulted in delayed completion as planned. He is currently finalizing his field work and is expected to graduate by the end of 2011.

In addition to graduate students, three undergraduate students conducted their final year bachelor's degree thesis in groundnut breeding. These included Mr. Prosper Gassinta and Mr. Harara of the Polytechnic of Katibougou, Mali) and Mr. Youssouf Camara from the University of Niamey, Niger.

Non-degree training

At the start of the project**,** ICRISAT-Mali conducted 2-day in-country training workshops in Mali, Niger and Nigeria in methods, and data capture. A total of 15 (5 in Mali, 2 Niger and 8 in Nigeria) benefitted from the training. A methods manual was prepared. A training module on crop management and seed production was also produced. This was shared with the project staff in partner countries.

A 10-day intensive training workshop on groundnut breeding methods and techniques was held at ICRISAT-Mali from 26 January to 6 February 2009 for research assistants and scientists. A total of eight participants (two from IER, Mali, two from INRAN, Niger, three from IAR, Nigeria and one from ICRISAT) attended the workshop. The course covered a range of topics organized in 10 modules. Two technical guides in groundnut breeding and PVS were prepared and their soft copies were made available to the participants. The project also contributed to the training of research technicians from IER, Mali, INRAN, Niger and ICRISAT-Mali in data capture and analysis using the GENSTAT statistical program from 9-20 February 2009. A total of 33 participants attended the training.

Degree training

Two PhD students (from Niger and Nigeria) at the West Africa Center for Crop Improvement (WACCI), University of Ghana, were mentored to formulate and present their thesis research project proposals in groundnut breeding.

Training farmers

Before the implementation of the PVS trials, a 1- to 2-day training session was conducted for the participating farmers in the respective locations. Group meetings were also held during field monitoring by the project staff. More than 2,000 persons including farmers and extension agents have benefitted from the training by the end of 2009. In 2010, a total of 150 women from the farmer groups in five villages in Sanakoroba district of Mali participated in a pre-sowing 2-day training program in good practices of producing groundnut. In addition, 10 village (all men) agents and 2 staff (1woman and one man) of PLAN-Mali also benefited from the training. ICRISAT-Mali provided the facility. IER-Mali facilitated training of 75 farmers in integrated crop management at the sites in the Kayes region where demonstration plots were established.

Establishing an efficient improvement program for NARS

At the beginning of the project no hybridization activity was conducted at any of the participating NARS. After the training of technicians in managing crossing blocks, and the rehabilitated facilities, hybridization has been initiated at INRAN and IAR

Farmer-friendly literature

ICRISAT prepared simplified brochures on varieties grown in Mali and crop management in French for eventual translation into Bambara.

Lessons learned/concerns

- The release of new breeding lines remains a very slow process. This is largely due to variety release committees not meeting or the NARS partners not being aggressive enough to promote new varieties through nationally coordinated trials and on-farm validation tests. However, through PVS the variety release process can be fast-tracked;
- The major challenge facing women groundnut farmers is the limited access to good land and farm equipment to reduce drudgery in the production and processing of groundnut;
- The project involves many sites - some in isolated locations - making coordination and monitoring a challenge. Focusing on one key region per county will be the most effective in terms of resource use and sustainability. Successful interventions can be replicated in other regions.

Constraints

The main constraints cited by the partners are:

- Lack of reliable transport to monitor activities, thus limiting the spread of activities;
- Lack of suitable cold storage to maintain seed in good conditions before planting;
- Poorly motivated technicians;
- Difficulty of identifying candidate for graduate degree training programs and the delays in starting course work;
- A lack of a critical mass of scientists in Niger and Mali to carry out groundnut breeding activities; and
- Fund disbursement procedures coupled with different accounting systems in the NARS has created challenges that can have a negative effect the full implementation of the project. his was the case for Nigeria.

Perspectives

The investments made by ICRISAT and partners over the last 15 years have generated valuable technologies and knowledge which is having a positive effect on the livelihoods of groundnut farmers in the target countries. This project will create a solid platform for sustainable up-scaling of the options and impact of these technologies and others in the pipeline**.** The second phase will include the full range of production, post-harvest, utilization and market development in each country to ensure that value-addition is addressed early and that producers also benefit through better market elasticity.

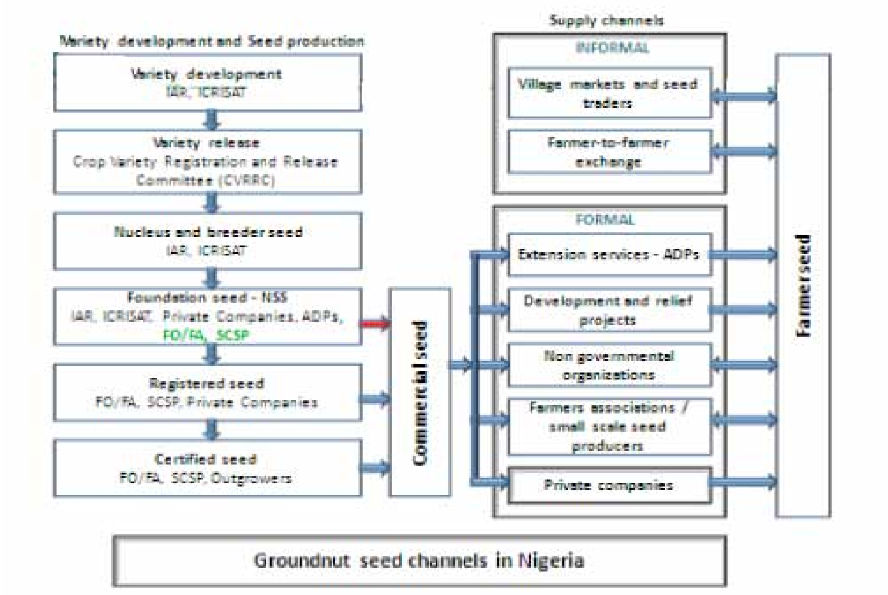
Seed Production and Delivery Systems

The major constraints limiting performance of groundnut seed systems in West Africa include:

- Limited access to seed of newly bred varieties;
- Limited supply of breeder/foundation/certified and commercial seed of varieties preferred by farmers or required by the markets;
- Seed production is subsidized and inefficient;
- Uncertain and thin seed demand;
- National variety release committees are missing, non-functional or meet irregularly;
- Weak integration between seed and product markets; and
- Lack of enabling policy and institutional environments.

Constraints to groundnut seed supply and delivery systems identified

For illustrative purposes, groundnut seed channels as well as institutions are mapped below in the case of Nigeria. Variety development is carried out by the Institute of Agricultural Research (IAR). Variety is released by the Crop Variety and Registration Committee (CVRC). While Breeder Seed production is the sole responsibility of IAR, Foundation Seed production is the responsibility of the National Seed Services (NSS) who contract other institutions such as IAR and the Agricultural and Rural Development Authorities of the state ministries of Agriculture commonly referred to as ADPs. Other classes of seed are produced by private companies and community based organizations (CBOs).



Seed production of all classes

A total of about 360 MT of certified seed of all classes were produced during the first phase of the project of which 8.5 MT were Breeder Seed, 212 MT certified seed and 57 MT basic seed and more than 100 MT of Quality Declared Seed.

Table 4-16. Trend on groundnut seed production (kg) in Mali, Niger and Nigeria (2007-2010).

Country		Year				Total
		2007	2008	2009	2010	
Mali						
Breeder			3152	2963	1715.5	7830.5
Certified		1220	20300	42700	58000	122220
Foundation			6298	5072	8581	19951
QDS			8000	14800	21400	44200
	Sub-total (1)	1220	37750	65535	89696.5	194201.5
Niger						
Breeder				173	517	690
Certified			11781	26999.5	25680	64460.5
Foundation			7722	10452	14174	32348
	Sub-total (2)	0	19503	37624.5	40371	97498.5
Nigeria						
Certified		756	4560	15800	4000	25116
Foundation				3389	1724	5113
QDS			7500	20200	10000	37700
	Sub-total (3)	756	12060	39389	15724	67929
Total quantity (kg)		**1976**	**69313**	**142548.5**	**145791.5**	**359629**

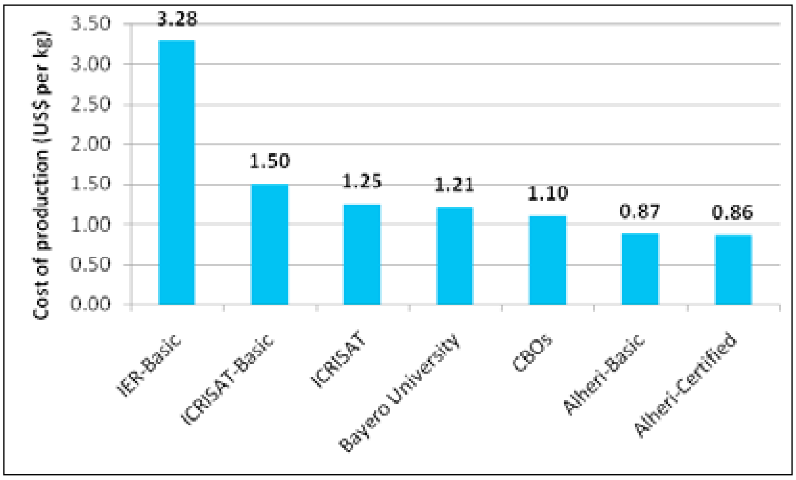
More than 60 farmers' organizations and small-scale seed producers were involved in seed production and marketing.

Strategies to enhance seed production and delivery schemes

To search for strategies to enhance seed production and delivery schemes, data on costs of seed production and delivery by all institutions involved in the seed chain were gathered. Basically, two schemes were pursued: the public seed multiplication and delivery scheme (NARS and traditional extension services) and CBOs (community-based organizations) including farmers' associations and small-scale seed producers.

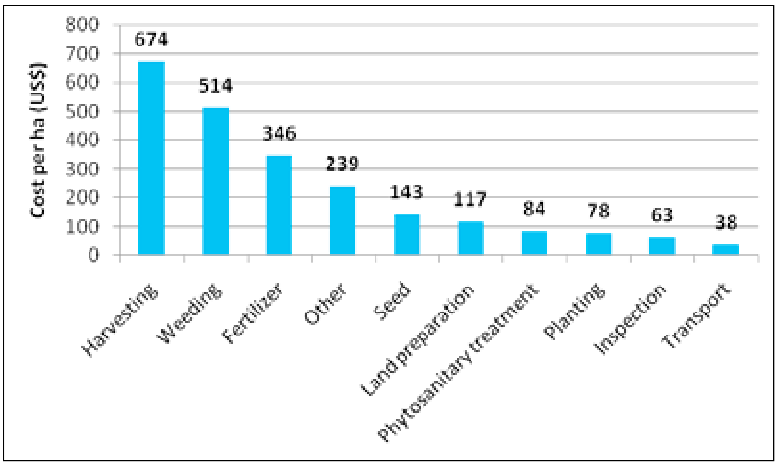
Results showed that seed production through the public sector institutions is very high. As illustrated in Figure 4.2, direct Foundation Seed production through NARS in their farms and managed by NARS personnel is very costly about US$ 3.28 per kg. However, seed production through contract growers can significantly reduce cost of seed production. Farmers' associations and small-scale producers can produce high quality Foundation Seed at lower costs, (US$1.10 per ha).

Figure 4-2: Cost of seed production by different institutions



The major cost items in seed production are manual harvesting, weeding, seed and land preparation. Opportunities for mechanization should be explored.

Figure 4-3: Average cost per activity performed



Based on the analysis of costs involved in seed production and delivery systems in West Africa, it is clear that the production of Breeder Seed should remain the responsibility of NARS. However, government commitment to support NARS in the production of Breeder Seed is essential. Revolving fund schemes within NARS should be supported by government to ensure sustainability. The production of Basic Seed through contract farming with small-scale seed producers and/or farmers' organizations with technical backstopping from NARS. The production of certified seed should be entirely the responsibility of Farmers' organization and small-scale seed producers.

Testing seed marketing strategies

A major marketing strategy tested includes the sale of small pack groundnut seed. This scheme was largely successful. More than 10,000 small pack seed was sold. Farmers revealed their preference for pack sizes of 0.5 kg to 1 kg and seeds that are treated. However, major differences in sales/profitability were found on the positioning of selling points, the level of knowledge of agro-dealers and small-scale retailers on marketing and business skills and agro-ecological zones. Sales were lower in drier areas compared to less drier ones. A report is available in the case of the Dosso region in Niger.

Training in seed production, marketing and management skills

More than 1000 farmers and extension agents were trained on seed production techniques per year. And more than 55 retailers/local seed producers from Mali and Niger were trained in small-scale seed marketing and business skills with the technical backstopping from WASA-SEEDS. It is not clear however, how many of these farmers trained are actually practicing what they have learned. This should be explored during the second phase of the project

During the next phase of the project, it is not clear how useful the training in seed production techniques would be; training in seed marketing and business skills should be largely emphasized.

Academic training

During the implementation of the project, Mr Diarra Mahamadou registered and obtained his MSc degree from the University of Ouagadougou, Burkina Faso. His thesis topic focused on the "Adoption of improved varieties in project sites in Mali".

Information themes/programs developed and disseminated

Supply and access to information by smallholder farmers remain a major constraint to adoption of technologies in West Africa. Baseline studies revealed that many smallholders are not aware of new technologies and among these, varieties. Even when they are aware, they do have information on the modern varieties and/or seed supply sources. In an attempt to reduce the information constraints, the TLII project has contracted with rural radios in the interventions sites to offer information on technologies and innovations to smallholder farmers. Thus, four radio program son crop management and seed production were developed by the RADIO Faraa in Gaya district and Radio Rounkououm in the Doutchi district of Niger. In addition to information on crop management and seed production, during the small pack sales between April and June each of year, information on improved varieties were offered to smallholder farmers. Supply of information has surely impacted on sales and access to seed by farmers in and around the project sites. This needs to be further explored in the second phase.

Enhancing Cowpea Productivity and Production in Drought-Prone Areas of Sub-Saharan Africa

Christian Fatokun (IITA-Nigeria); Ousmane Boukar; Alpha Kamara; Ousmane Coulibaly; Arega Alene (IITA-Malawi); Steven Boahen (IITA-Mozambique); R. Bandyopadhyay (IITA-Nigeria); L. Kumar (IITA-Nigeria); Z. Kouyate (IER); L. Omoigui (UAM); S. Gimba (KADP); Umar Garba (KNARDA); S. Dioffo (SNV); Robert Abaidoo (IITA-Nigeria); Satoru Muranaka (IITA-Nigeria); Mamadou Touré (IER-Mali); Moutari Adamou (INRAN-Niger); Mohammad Ishiyaku (IAR-Nigeria); Joseph Mligo (ARI-Tanzania); Manuel Amane (IIAM, Mozambique)

Socio-Economics/Targeting

Summary

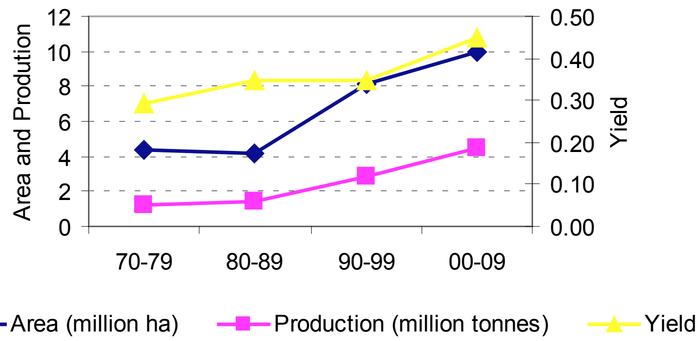
Efforts aimed at raising the productivity and incomes of smallholder farmers should involve developing technologies that address key production constraints and have the traits that are highly preferred by various end users. A growing volume of empirical work has demonstrated that farmers are unlikely to adopt new varieties and other technologies that do not meet their own criteria. While other institutional and policy factors may hinder the uptake of otherwise profitable crop varieties, addressing the needs and priorities of smallholder farmers and other actors along the value chain is the necessary condition for greater technology uptake and impacts. Better technology targeting thus helps investors achieve greater rates of return on their investments. The cowpea component of Objective 1 thus aims to facilitate the proper targeting of cowpea breeding activities with a view to maximizing adoption and poverty impacts of the resulting technologies. Targeting activities largely involve baseline data collection and analysis (household and market level), trait preference assessment, seed systems and monitoring of technology uptake processes to better inform breeding and seed dissemination efforts. The baseline studies include characterization of production systems using household surveys, situation and outlooks for cowpea using aggregate production and trade data, and identification of priority traits for farmer groups and markets using PVS. Adoption surveys to monitor uptake and impact should be undertaken following significant multiplication and distribution of improved seeds of released varieties.

Cowpea facts, trends and outlook

Globally, an estimated 6.5 million MT of cowpea is produced annually on about 14.5 million hectares. Africa accounts for about 83% of the global cowpea production, with over 80% of Africa's share produced in West Africa. With an estimated 45% share of the global cowpea production and over 55% of the production in Africa, Nigeria is the world's largest producer (and consumer) of cowpea, followed by Niger (15%), Brazil (12%), and Burkina Faso (5%). During the past three decades, cowpea production grew at an average rate of 5% annually. With 3.5% annual growth in area and 1.5% growth in yields, area expansion accounted for 70% of the growth in global cowpea production over the last three decades. Globally, the share of cowpea in total area under pulses grew from less than 10% in 1990 to nearly 20% in 2007. In West Africa, cowpea occupies over 85% of the area under pulses and 10% of the total cultivated land.

Area

Global trends in area under cowpea production are shown in Figures 5-1 and 5-2. Although cowpea global area cultivated has had an upward trend since the 1970s, it increased markedly in the 1990s. From an average of about 4 million in the 1970s and 1980s, the areas increased to 8 million in the 1990s and further increased to 10 million in the 2000s. From 1970 to 2009, area planted increased by 0.24 million ha per year. While the area planted to cowpea temporarily plummeted towards the closure of the 1970s perhaps following the 1973/4 oil cartel which may have undermined global cowpea demand through its negative impact on incomes, areas increased from the 1980s through to 2009 part of which may be explained by the advances in plant breeding which saw a number of important varieties being released within the period following the work by IARCs and NARES. Indeed due to work by IITA in collaboration with IARCs and NARES, reports show that Nigeria, the world's major cowpea producer, did experience marked increases in harvested areas and cowpea yields between 1970 and 2009.



Source: Authors using FAO data

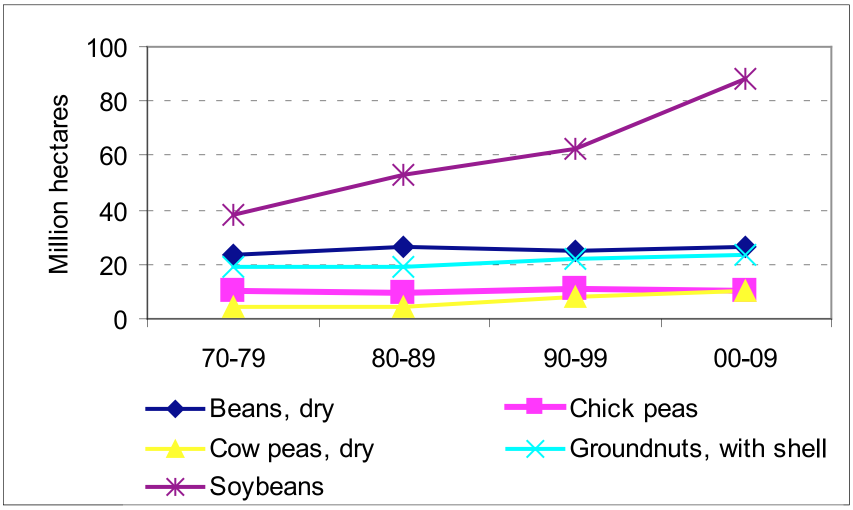
Figure 5- 1: Global trends in cowpea area, yield, and production, 1970-2009

The production differences that exist from one country to another are also attributable to the fact that recommended varieties vary across countries and also have varying yield potential. For instance, while the bulk of recommended varieties for Nigerian conditions are early maturing, most varieties recommended for Niger are medium maturing and have different yield potential when compared with those recommended for Nigerian drier conditions. Inter-temporal variations/fluctuations in terms of areas harvested and yield may reflect the effect of time-varying environmental and policy changes in the major growing countries. Intermittent dry spells and good rainy seasons for example coupled with changes in pests and disease prevalence over time in West and Central African region may partly explain such areas fluctuations, though the steady increase in production may be attributable to the effect of technological progress on productivity.

Figure 5-2 indicates that compared to other major legumes, the area cultivated for cowpea has been low. However, it increased gradually as observed for most of the other legumes as well. In the 1970s, it had the lowest area cultivated (4 million ha) with the next in size being chickpea with 10 million ha. However, the area for chickpea remained close to the 1970s value so that by the 2000s cowpea had become as large as chickpea in terms of area cultivated. In the 2000s, they both had an area of about 10 million. The increase in area for soybean has been much higher than that for other legumes. Its area cultivated increased markedly from about 40 million in the 1970s to about 90 million hectares in the 2000s.

Total area cultivated for cowpea in Africa is 9.7 million hectares. Thus, Africa accounts for 84% of global area cultivated. The bulk of this is found in West Africa. Thus West Africa is the major region in terms of area cultivated. Asia accounts for 1.5% of global area (0.2 million ha) while the rest of the world accounts for about 1%. In West Africa, Niger, Nigeria and Burkina Faso have the largest areas.

Nigeria and Niger each account for about 40% of global area cultivated (about 4 million hectares each) while Burkina Faso accounts for 7% (0.7 million ha). As such, these three countries account for the bulk of area cultivated in West Africa and globally.



Source: Authors using FAO data

Figure 5-2: Global trends in area under major legumes, 1970-2009

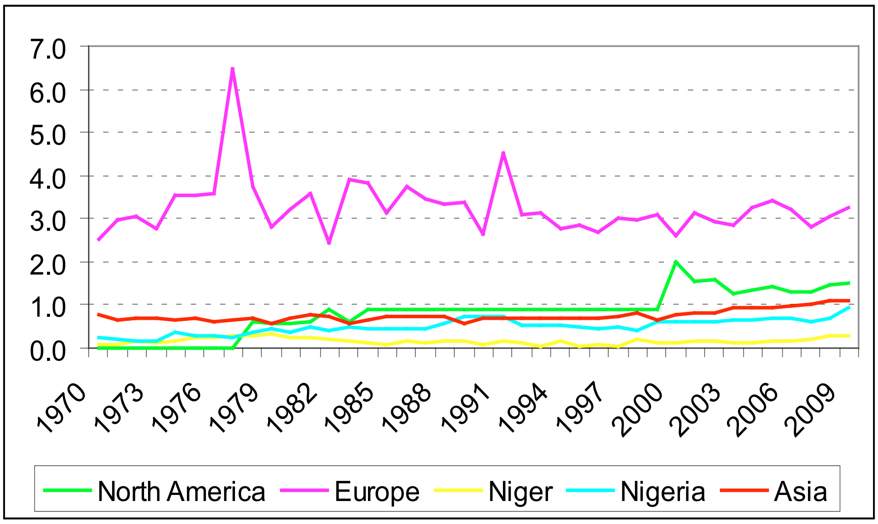
Relative to the other regions, the West African region has also seen appreciable changes in the area planted to cowpea in the last four decades. With an increase of 5 million hectares in area planted to cowpea, the West African region registered the highest area growth in the world. It is distantly followed by the East African region where areas increased by 0.3 million. With area increase of 3 million hectares, Niger's area expansion dwarfed not only the other West African major world cowpea producers (Nigeria and Burkina Faso), it was also larger than total area increases in other individual countries and continents.

Nigeria and Burkina Faso saw area increases of 1.2 million ha and 0.4 million ha, respectively, and together with Niger made the West African the region where cowpea area expansion was the greatest. Cowpea area expansion in Nigeria, Burkina Faso and Niger may be attributed to the need for more production to meet the growing regional demand fuelled by growing incomes and population especially in Nigeria and partly Ghana, in the absence of real changes in technical progress and productivity.

Yield

World cowpea yields have generally been low compared to potential yields and below 1 MT per hectare although there has been an increase from around 0.3 MT per hectare in the 1970s to about 0.45 MT per hectare in the 2000s (see Figure 5-1 and 5-3). However, wide disparities exist across continents and sub-regions with yields ranging from 0.4 MT in West Africa to 3 MT per hectare in Europe in the 2000s. In the last 4 decades, the yields in West Africa have mostly been below those in other parts of globe. Because West Africa accounts for about 90% of global area cultivated, average global yields reflect its relatively low yield. The highest yield in Africa is observed in North Africa at .9 tonnes/ha. North America (the United States in particular) has a yield of 1.5 tonnes/ha. Although West Africa dominates in terms of area cultivated, it clearly lags behind in terms of productivity. In Asia the yield is also higher than that of West Africa at 1.5 tonnes/ha. Although Europe, North America and Asia have higher yields, they account for less than 2% of global area cultivated.

Figure 5-3 shows that Nigeria made some progress in increasing its cowpea yields from 0.2 MT per ha in 1970 to 0.9 MT per ha in 2009. In contrast, Niger has made much slower progress with its yield increasing from 0.1 MT per ha in 1970 to 0.3 MT per ha by 2009. In fact, since 1970, Niger's yields have fluctuated between 0.1 MT per ha and 0.3 MT per ha with the latter being experienced in six years only in the last four decades. Thus, Nigeria increased its yield by 0.7 MT per ha while Niger increased its by 0.2 MT per ha during the same period. These increases in yields in Nigeria may be explained by the limited adoption of newly released varieties although this has happened only on a small scale. Although yields in Europe have shown some fluctuation, they have generally been much higher than those in Nigeria, Niger and other regions of the world. The yields in Asia and North America have also been higher than those in Nigeria and Niger for many decades. This may be an indication of an opportunity to increase yields to levels closer to what is obtained on other continents.



Source: Authors using FAO data

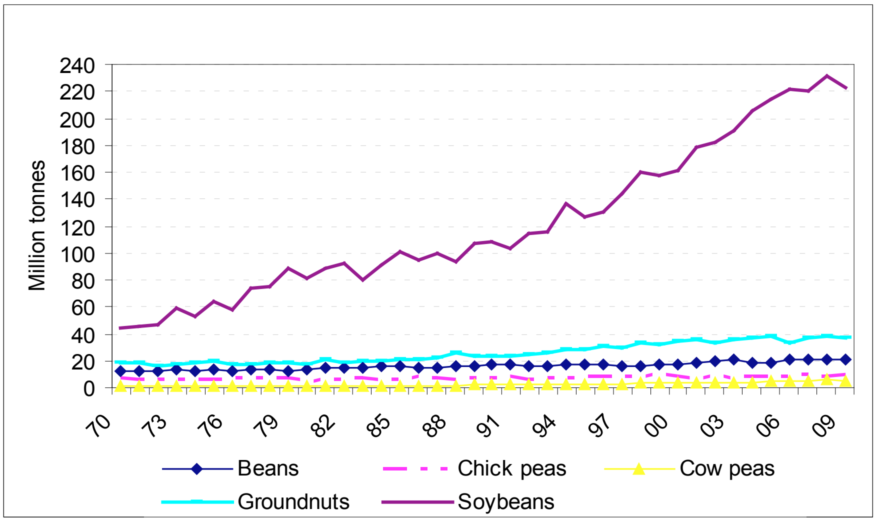
Figure 5-3: Trends in cowpea yields across the world 1970-2009

Production

Figure 5-4 shows that global cowpea production has steadily increased from an average of 1.3 million MT in the 1970s to about 4.5 million MT in the 2000s representing an annual average production growth rate of around 4.7%. With a production growth rate of 28.9%, North America saw the highest growth rate while the Caribbean recorded the lowest growth rate of about 0% with the 2009 production level being 60% of the 1970 level. West Africa recorded a growth rate of 4.9% while Asia and Europe recorded 5.9% and 7.9%, respectively. Since the 1970s cowpea production never exceeded 2% of production of major legumes. Figure 5-4 indicates that soybeans, groundnut and thirdly beans have been the dominant legumes in terms of production levels. Soybean in particular has experienced very large increases in production since 1970 with an increase from about 40 million MT to about 220 million MT by 2009.

Of the 4.5 million MT average global production in the 2000s, Africa accounted for 95% (4.3 million MT). Asia and Europe accounted for 3% and 1%, respectively, while the rest of the world accounted for about 1%. Although North America has had the highest growth in cowpea production, its production share was not up to 1% in the 2000s.

Although Niger had the largest area under cultivation of 4 million hectares in the 2000s compared to the 3.8 million hectares cultivated in Nigeria, Niger's production was much lower at just about 770,000 MT compared to the 2.6 million MT of Nigeria. Among the factors that determine cowpea production at national level in West Africa are the level of technology, cost of input (price/unit) for cowpea production, prices of alternative crops, agro-ecological adaptations, and government policies (especially with regard to incentives aimed at promoting cowpea production).



Source: Authors using FAO data

Figure 5-4: Global trends in production of major legumes, 1970-2009

It is indeed said that as result of research focused on supply-side factors, the share of cowpea production among various grain legumes in Nigeria has increased since 1988, making Nigeria the largest cowpea producing country in the world8. These factors have contributed to the wide disparity in productivity levels with Niger having an average yield of 0.2 tonnes per hectare and Nigeria having 0.7 in the 2000s. In addition to yield differences, the fact that Nigeria has a large population and cowpea as a food item is popular implies that there are many internal incentives within the country for stimulating production. These factors have led Nigeria to be the largest producer as well as consumer of cowpea globally.

If past trends in cowpea area expansion and yields continue into the future, global cowpea supply is projected to reach 9.8 million tons in 2020 and 12.3 million tons in 2030, against the projected global demand of nearly 8.5 million tons in 2020 and 11.2 million tons in 2030. In West and Central Africa, which accounts for over 75% of global cowpea production, cowpea supply reaches an estimated 7.9 million tons in 2020 and 9.7 million tons in 2030, against the projected demand of nearly 7 million tons in 2020 and 9 million tons in 2030. The baseline projections of cowpea supply and demand thus show that, with historical area expansion and yield growth rates, cowpea production in West and Central Africa will keep up with growing regional demand for cowpea due largely to increased demand in countries such as Nigeria that will face the greatest deficits domestically. In West and Central Africa, cowpea demand is projected to grow at a faster rate of 2.68% per year than supply (2.55%) over the period 2007-2030. The alternative scenario represents a situation where future increases in cowpea production would come only from area expansion—a scenario consistent with cowpea's increased compatibility as a niche crop with cereals such as sorghum and millet with potential for area expansion into drier and more marginal areas, particularly in West and Central Africa. Under this scenario, global as well as regional cowpea supply will fall short of demand. The projections of cowpea supply and demand under this alternative scenario show that global cowpea supply reaches an estimated 7.9 million tons in 2020 and 8.9 million tons in 2030, against the projected global demand of nearly 8.5 million tons in 2020 and 11.2 million tons in 2030. With a regional supply of only 6 million tons in 2020 and 6.9 million tons in 2030 against the projected demand of nearly 7 million tons in 2020 and 9 million tons in 2030, West and Central Africa will face much greater deficits. Under this scenario, cowpea supply will grow at a slower rate of 1.33% per year than demand (2.68%) over the period 2007-2030. The projections suggest that increased investments in cowpea research and extension will be key to generating a regional surplus through increased yields, whereas regional trade in cowpea will be crucial for achieving food security through redistribution of the surplus thus generated among countries in West and Central Africa.

Baseline studies

The objective of the baseline studies is to establish the current food security and poverty status of the cowpea and soybean producing households and to document the importance, constraints, and variety preferences relating to cowpea and soybean production. The baseline information is intended to facilitate project monitoring and impact assessment in terms of technology adoption, yields, incomes, food security, and poverty. A greater understanding of the production and market constraints and preferences would also help identify appropriate technology and policy options to enhance the benefits from cowpea and soybean production through increased productivity and incomes. An important aspect of the baseline studies is the design of the baseline survey such that information on target as well as control villages and households would be available before and after the project. The approach accounts for conditions with and without as well as before and after the project and forms part of an overall monitoring and evaluation framework aimed at measuring and attributing the short term and long term impacts of the project using rigorous methods. Baseline household survey questionnaires have been developed to gather baseline data on: (1) basic farm and household characteristics; (2) cropping patterns, input use, production, and yields; (3) non-farm employment and incomes; (4) food and non-food consumption; (5) vulnerability and coping strategies; (6) gender roles in food production and marketing and women's access to productive assets and financial resources; (7) cowpea and soybean varietal adoption and trait preferences; (8) cowpea and soybean seed systems; and (9) soybean processing and marketing. In addition to questionnaires, other supporting tools included improved and local seed samples and GPS equipment.

Targets were achieved through four major activities. First, baseline studies involving household surveys were conducted across target countries to establish the current food security and poverty status of cowpea producing households and to document the importance, constraints, and variety preferences relating to cowpea production. The baseline information is intended to facilitate project monitoring and impact assessment in terms of technology adoption, yields, incomes, food security, and poverty. An important aspect of the baseline studies was the design of the baseline survey such that information on target as well as control villages and households would be available before and after the project. The approach accounts for conditions with and without as well as before and after the project and forms part of an overall monitoring and evaluation framework aimed at measuring and attributing the short term and long term impacts of the project using rigorous methods. Second, standardized PVS survey tools on end-users' trait preferences were designed and were co-implemented by breeders and socio-economists. Third, secondary data relating to cowpea production and trade were assembled from various sources and analyzed to establish the production system and market outlook for cowpeas in SSA. Fourth, seed systems surveys were conducted involving key market actors throughout the cowpea value chain. IITA is implementing the project in partnership with NARS from Mozambique, Tanzania, Nigeria, Niger, and Mali that are involved in active cowpea improvement research. In addition, farmers and other stakeholders in the targeted legume crops are involved in the selection of breeding lines with drought tolerance and other desirable attributes especially those that are attractive to end users.

Baseline surveys were conducted in the same areas where PVS and seed multiplication activities were carried out to ensure that early adoption and impact assessment will be undertaken in the same areas where early adoption would most likely occur. Sample villages varied from 10 to 20 according to the size of sites with an average of two-thirds of villages selected randomly from a list of major cowpea or soybean growing areas and one-third of them were used as control villages. An average of 15 households was randomly selected in each village. The sample households varied from 150 to 300 households.

In Malawi for instance, a total of 300 households were selected for baseline study and female-headed households accounted for 24% of the sample households.

Major results from baseline surveys: cropping systems and perceptions

Cowpea production, processing and marketing in West Africa take place in an ever-changing environment and so does agricultural research. However opportunities are arising from economic growth and regional trade. Income drives the demand for high-quality cowpea and soybean grains and processed products. Biotic and abiotic constraint like pests, diseases, drought and market access mainly for cowpea are threats to food security, poverty reduction and enhanced livelihoods. Research priorities need to be updated to take into account these constraints and opportunities. This will require ex ante impact assessment aimed at identifying potential gains from technologies and novel institutional arrangements and priority setting.

Eastern & Southern Africa (Tanzania & Mozambique)

- About 62% of the sample households in Mozambique live below the poverty line and 58% are food insecure. Consistent with their poorer access to land and lower adoption of improved varieties, female-headed households in Mozambique are relatively poorer than male-headed households. The target households are as poor and food insecure as the control households, implying that the project has rightly targeted relatively more needy households.
- Average farm level cowpea yields barely exceed 500 kg/ha, much lower than the potential yield of 1.5 to 2 MT per ha obtained in on-farm trials.
- The most important source of information on improved cowpea varieties is fellow farmers. Over 80% of the adopters in Mozambique mentioned another farmer/neighbor as being their main source of information on varieties IT-18 and IT-16.
- Cowpea variety IT-18, which was introduced long ago, is the ruling or most popular variety in Mozambique
- Over 50% of the sample households in Mozambique have adopted the cowpea variety IT-18. Female-headed households tend to have relatively lower adoption rates of cowpea (40%). Only 12% of adopters of improved cowpea varieties bought improved seed from agro-dealers, with the rest using their own recycled seed.
- Grain yield and earliness/drought tolerance are the most referred traits. Over 60% of cowpea producers in Mozambique prefer varieties with high grain yield, whereas those in Tanzania prefer varieties with high grain yield as well as early maturing or drought tolerant. While price and taste are distant second and third important traits overall, female-headed households prefer cowpea taste to its price, confirming the importance of cowpea as a food crop.
- Over 70% of non-adopters of improved cowpea indicated lack of access to improved seeds as the major constraint.
- Drought is the main source of vulnerability both in Tanzania and Mozambique, followed by pests and diseases. The ex-ante risk management options include crop diversification, planting more cassava than maize, and off-farm work such as petty trade. The ex-post coping options include reduced number and quantity of meals, borrowing money to buy food, and switching to cassava.
- Women own nearly 50% of the land and livestock and undertake most of the farming activities, particularly threshing, seed selection, and storage, but marketing is done by men, both food and cash crops, with obvious patterns of control of cash income by men. Overall, the survey results suggest that, despite their ownership of assets, women have no control over their productive assets and the resulting incomes.

West Africa (Nigeria, Niger, and Mali)

- Availability of labor is a main cowpea production constraint in West Africa. In Mali, 44% of Male-headed household estimate that family labor availability is determinant in cowpea production, while in Niger, it is 19% of Male-headed household.
- In Nigeria, 71% of Male-headed household report the lack of cash availability to purchase seeds

and other inputs.

- Popular varieties (widely disseminated in each country) include: Mali: IT 89DE-58-6 and KVx542-119 resistant to Striga; CZ11-94-5C and CZ11-94-32 resistant to drought and Striga. Nigeria: IAR-1696 with high yielding potential. Niger: HTR and TN 27-80 resistant to the major pests. Other new varieties recently released to farmers in Mali include IT97K-818-35, IT95M-1072-57, and C94-23-2.
- Despite the high potential yield for improved varieties of 1.5 to 2 t/ha, the average farm level yields range from 500 kg/ha to 600 kg/ha for local varieties.
- Main preferred traits of improved cowpea varieties are yield potential, pest/disease resistance, performance under poor rainfall, superior storage pest resistance, grain size, yield stability, early maturity, and drought tolerance.
- Major constraints to cowpea production include insect pests, erratic rainfall, and parasitic weeds such as Striga, with insect pests like Maruca pod borer causing the most important losses of up to 100%. Poor physical and economic access to inputs such as seed is another constraint due to low purchasing power and underdeveloped input markets. Seeds of improved varieties are not widely available.
- Most of the households (84%, 94% and 64% respectively in Nigeria, Niger and Mali) report that the main decision makers in rural household (mainly the crop production decisions) are the heads of household who are very often men.
- In Niger, the decision about the choice of varieties is mainly made by the household head (60%). According to the desirable characteristics for ideal cowpea based on gender, 44% of men and 38% of women prefer high yield. Other characteristics like pest resistant, size of grain and early maturity did not have the same importance according to gender. Men give importance to size of grain while women prefer early maturity grain. The predominant cowpea variety in markets, based on grain colour, is white (49%) and red/brown (45%) with brown/grey eyes (97%). Sixty two percent (62%) of farmers estimate that cowpea varieties planted yield poor fodder.
- In Niger results show that only 26% of farmers have participated to farmers fields' days.

Major results from baseline surveys: seed supply systems and demand constraints in target countries

Nigeria

Since most of the projects include a seed system component, the seed system study covers 3 states (Borno, Kano and Kaduna) and 2 crops (cowpea and soybean). In Kano and Katsina States, availability of quality seeds of the main cereal and legume crops has been identified as a key constraint to adoption of new varieties. Knowledge of the current seed systems in the project area is an initial necessary step to address the seed availability problem. In Borno State, prior to PROSAB and CIDA funded project, the only improved seeds available to farmers were maize hybrids which are not resilient to the constraints in these drought-prone areas. To mitigate drought and striga impact, IITA introduced a number of improved crop varieties in Borno, Kano and Katsina including maize, sorghum, rice, cowpeas, soybeans and groundnuts. Most of producers, 60% in Kano state and 86% in Borno state, get information from the ministry of agriculture through extension agents. Few producers get information from Seed company and NGO in Kano and very few from research institute staff and fellow farmers. Efforts should be made in using radio channel (1%) for improved seed variety diffusion since almost all of households (100%) have radio. To ensure ongoing availability of improved seeds, PROSAB selected and trained seed producers and assisted them in establishing community-based seed multiplication schemes in 30 communities in southern Borno covering three agro-ecological zones. There are prospects that some of these seed producers will develop self-sustaining rural enterprises with capacity to meet the demand for improved varieties seeds for farmers within and around the communities. Considering the variety attributes, more than half of farmers focus their choice on high yield. While 37% of farmers report that cowpea varieties have a poor grain yield. However, access to quality (13 and 9% in Kano and Borno respectively), affordable, and sustainable improved seeds remains a concern.

Niger

Seed systems in Niger vary substantially in their institutional and legal aspects and in their operational procedures. In Niger, plant breeding and breeder seed production are undertaken by the national agricultural research system, 'Institut National de Recherches Agronomiques du Niger (INRAN). Breeder seed are bulked into foundation seed by the SPC of Lossa. Foundation seeds are multiplied further into registered or commercial seed by four other seed multiplication centers through contract farmers. Seed is distributed through a few sales points located in the capital cities of departments, research centers, and seed production units, and to a lesser extent, NGOs. Seed quality control activities for breeder seed and basic seed are performed by the SPC of Lossa and for other seed classes by the other SPCs. Seed processing, storage, and control are undertaken by the SPCs in their laboratories and processing units. Overall, the mode of seed provision is dominated by the public sector and has remained so since 1975 when the first seed project (the Niger Cereal Project, PCN) was launched. The only major change in the system occurred in 1989 when seed production planning, distribution, and price-setting decisions were decentralized at the departmental level. Currently, almost all activities are still performed by government agencies. In Niger, variety evaluation and release are the responsibility of INRAN.

Mali

In Mali, grain markets have been liberalized with measurable success, but the liberalization of seed markets for sorghum, millet and cowpea (the staple crops) has proven to be more difficult. Despite continuous progress by scientists in breeding well-adapted, high-yielding commercial seed varieties, only an estimated 10% of Mali's millet and cowpea area and less than 20% of its sorghum area has been planted with certified seed. This is because many smallholders have limited or no access to certified seed and because they have also been long accustomed to generating their own seed or supplying each other with seed according to clan or ethno-linguistic group. Traditionally, these informal seed systems work quite well, but researchers were surprised to discover that in areas subject to harsh agro climatic conditions, successive crop failures have caused village seed systems to break down, and local grain markets have become important sources of seed. This finding led IFPRI researchers to examine seed transactions in a dozen weekly markets in the Sahel region of Mali. They found that no certified seed is available in these markets, but that grain suitable for seed is being sold by primarily female vendors who are also farmers. Because the vendors bring unmixed seed directly from their granaries, the purchasers know the provenance and can depend on its quality, which is especially important in harsh environments where the range of adaptability is very limited. The grain colour plays an importance in the preference of consumers. The predominant grain colour in visited markets is white. Sixty four percent (64%) of cowpea varieties used by farmers are white and 79% are black eyes.

Malawi

In Malawi, the Department of Agricultural Research Services (DARS) is responsible for the production and distribution of basic or foundation seed. However, the level of investment is so variable and usually leads to erratic supply of basic seed. No adequate basic seed was available at the start of 2007 season such that multiplication had to be done using certified soybean seeds. Currently, production is undertaken under the DARS Basic Seed Up-scaling Program. Potential farmers apply and successful applicants are then supplied with breeder seed to produce basic seed under inspection of the Seed Services Unit. The basic seed is then sold through the program management unit. In 2008, nearly 7 tons of basic soybean seed was produced. The up-scaling program signals the public sector efforts to improve the production and distribution of basic seed of soybean. As opposed to past basic seed production initiatives, the up-scaling program is more organized. For instance, the varieties that are multiplied under this program are chosen based on farmer and consumer preferences and the seed production is undertaken by farmers with inspection and other technical support from the Seed Services Unit.

Mozambique

Soybean seed multiplication is solely undertaken by community-based associations that are members of IKURU. IKURU is a farmer-owned commercial entity that works with local out grower associations for cowpea and soybean in Nampula and Zambezia provinces. It procures basic seed of cowpea—mainly IT-18—from the Basic Seed Unit of IIAM (USEBA) and basic seed of soybean—mainly Santa and Storm—from a seed company in Zimbabwe and distributes it to farmers through the affiliate associations. All the seed multiplied under this scheme is sold to IKURU after it has been thoroughly cleaned and treated with actellic dust. The seed is later sold to agro-dealers, government projects, and NGOs at a wholesale price while part of it is sold on the retail market through IKURU retail shops. In a situation where most of the farmers rely on their own farm-saved, recycled seed, lack of effective improved seed demand will continue to be a critical constraint to the development of the seed sector. There is no premium price for improved seed and hence seed subsidies may need to form part of the overall strategy to promote adoption of improved varieties. Seed credit or subsidies, coupled with greater popularization activities, is thus needed to create awareness and market demand for improved seed. Apart from lack of economic access, many farmers also have neither the information nor the physical access to improved seed. Therefore, improved access to credit, extension, and information and market infrastructure would be a key component of an overall strategy aimed at enhancing farmer access to improved seed and other complementary inputs.

Early adoption studies in Nigeria

Results from adoption studies of cowpea technologies in Northern Nigeria where many cowpea projects have been carried-out indicate that 72% and 81% of farmers from Borno and Kano states, respectively, have adopted improved cowpea varieties like IT89KD-288, IT90K-277-2, IT97K-499-35 and IT89KD-391.The study results show also that over 60% of adopters of improved varieties were informed about improved varieties before adoption. The study results show that farmers' participation in previous cowpea projects is important in the adoption of innovations. Frequent contacts with extension and/or research agents, members of a community-based organization or cooperative, or those who have access to seeds of improved varieties make a farmer more likely to adopt improved varieties. Also, farmer-to-Farmer channel plays an important role in cowpea adoption. In Borno State, Farmer-to-Farmer extension accounts for 23%, while in Kano (9%) as source of information on improved varieties. Farmer-to-Farmer extension is an informal system in which individual farmer in a community assists other farmers by sharing information on seeds of improved cowpea varieties with other farmers in the community. In addition, the education level, years of experience in cowpea production and land availability have significant positive effects on the farmers' likelihood of adopting improved cowpea varieties. The study shows that farmers have also adopted improved storage technologies. More than 79% and 57% of the sampled farmers in Borno and Kano, respectively, have been using double or triple bagging and hermetic drums. The study concludes that there is a need to enhance the dissemination of newly developed varieties such as IT89KD-288, IT90K-277-2, IT97K-499-35 and IT89KD-391 and storage technologies on large-scale across other rural communities through effective and efficient production and dissemination of seeds and triple bags (Amaza, 2010). The early adoption studies will be undertaken in Eastern and Southern Africa in the second phase of this project.

Human capacity building

More than 40 Enumerators in total or 20 enumerators were trained per country in baseline surveys methodology and questionnaires-seed systems analysis and early adoption of cowpea and soybean improved varieties (as shown in Table 5-1 below).

Table 5-1: Number of trained technicians and enumerators in West Africa

Countries	Enumerators	Technicians	Total
Nigeria	60	6	66
Niger	20	2	22
Mali	20	2	22
Total	100	10	110

Challenges and vision

Major challenges

- NARS partners, especially in Southern Africa, have little or no capacity for socio-economics and impact assessment.
- Delays in report: It is observed and commonly reported that there is an undue delay in submission of reports, progress of work and work plans by the partners in all regions and locations.
- Coordination has been time consuming and involves high transaction costs (than anticipated).

Major lessons learned and vision for second phase

Lessons

- Too many TLII activities by country and crop led to inadequate resources per activity and country. With inadequate resources to involve consultants/fellows, PIs spread out too thinly with little or no NARS partner support (e.g. no senior economist with Malawi and Mozambique NARS available for TLII studies)
- Lack of focus for TLII socioeconomics work (seed systems, PVS, markets, baseline, adoption, situation and outlook, etc, etc.)

Vision

- Carryout early adoption and diffusion studies of improved varieties of cowpea at the beginning of the second phase.
- Carryout impact assessment of the TL II project on poverty reduction towards the end of the second phase of the project.
- Focus on selected high potential impact areas for the socioeconomic and impact studies
- Organize impact assessment short courses in West Africa and East Africa for NARS economists as well as consultants and fellows
- Establish linkages with Advanced Research Institutes for hosting PhD students and visiting fellow to undertake adoption and impact studies under the co-supervision of senior TLII economists

Breeding

Introduction

Cowpea is a crop grown mainly in dry savanna regions of Sub-Saharan Africa (SSA) where it is also indigenous. According to FAO statistics, about 4.34 million metric tons (MT) of grain is produced in West Africa out of a world total of 4.99 million tons on 9.30 million hectares. The average grain yield in the sub-region is approximately 470 kg per ha. The average yield in Nigeria is estimated at 690 kg per ha which has been attributed to the adoption by farmers of improved varieties. Cowpea can produce up to 1.5 MT of grains per hectare when plants are grown sole in appropriate spacing and protected against insect pests. Apart from a number of insect pests (aphids, flower bud thrips, legume pod borer and pod sucking bugs), two parasitic flowering plants – *Striga gesnerioides* and *Alectra vogelii* - cause grain yield reductions in cowpea. Cowpea performs relatively better than most other legume crops in the drought-prone areas of SSA. This-not-with-standing its grain yield could be adversely affected by drought which may occur at different stages in the crop's growth in the field. Rainfall pattern in the dry savanna regions, where the bulk of cowpea is produced, is generally erratic, especially early in the cropping season. In certain years farmers sow their cowpea seed in fields a number of times because of irregular rainfall early in the cropping season which may cause death of emerged seedlings especially if the interval between two rains is long. The cowpea plants may also be subjected to terminal drought due to short raining season which is becoming more frequent in the dry areas of SSA. Irrigation facilities are very limited in this region and where they are available high value crops such as vegetables are given priority over cowpea. Hence cowpea production depends almost entirely on rainfall. Thus the development and deployment of more drought tolerant varieties would help farmers obtain better and more stable grain yield from their cowpea plots. In order to develop more drought tolerant varieties it is necessary to identify cowpea lines with enhanced levels of drought tolerance. These would serve as parents for crossing to lines which have already been accepted by farmers. The thrust of this project is to enhance cowpea productivity in the dry savanna regions of SSA through genetic improvement.

Targets achieved in this project:

- Current cowpea breeding lines have been evaluated for their drought tolerance and the more drought tolerant lines were selected with farmers' involvement. Seeds of these lines were multiplied and made available to farmers to grow and compare with their own varieties. The selected varieties outperformed farmers' own varieties at all locations.
- More than 200 kg seed of selected lines with enhanced drought tolerance was produced and used in trials in at least 30 communities.
- Over 1,000 germplasm lines were evaluated in the field for their drought tolerance.
- About 20 lines with enhanced drought tolerance were identified and crossed to existing breeding lines with farmers and consumers preferred traits.
- Over 200 populations segregating for drought tolerance, and resistance to Striga have been generated. These are still being advanced.
- DNA markers (SNPs) associated with drought tolerance, bacterial blight and Striga resistance identified in the TL I project at UC Riverside were validated at IITA.
- A report on assessment of gaps in collaborating scientists, extension agents and farmers' skills was produced.
- Early adoption studies of improved cowpea varieties were carried out in Nigeria.
- Support for upgrading drought screening sites was provided in each country based on their needs.
- Five national programs are now active in breeding cowpea for drought tolerance.
- One stakeholders' workshop and two community workshops were held each year in each country to plan activities and receive feedback from stakeholders.
- One thousand eight hundred and ninety two (1,892) farmers participated in participatory variety selection (PVS) in identifying drought tolerant lines possessing desirable traits in five countries.
- Seven graduate students have been or are being trained at (6) MSc and (1) PhD levels in plant breeding.

Activities

There were three main activities undertaken in cowpea research and development during this phase of the project, namely:

a) Testing existing cowpea varieties and lines for their drought tolerance
b) Creating segregating populations for drought tolerance and attendant traits and
c) Strengthening capacity of NARS scientists

Testing existing cowpea varieties and lines for their drought tolerance

Several cowpea breeding lines on the shelves at NARS and IITA breeding nurseries were selected and tested for their drought tolerance on-station. Those with enhanced levels of drought tolerance were further selected for testing on farmers' fields in the five target countries.

Cowpea lines evaluated for drought in farmers' fields

Table 5-2 shows the number of elite cowpea lines tested in the different countries. There were however 16 common elite lines (IT00K-1263, IT99K-1122, IT96D-610, IT98K-491-4, IT89KD-288, IT98K-311-8-2, IT98K-166-4, IT99K-216-24-2, IT99K-7-21-2-2, IT98K-412-13, IT98K-390-2, IT98K-628, IT97K-819-118, IT99-529-1, IT97K-1069-6 and IT98K-128-3) tested in all countries. These 16 lines were from the early maturing, dual purpose, Striga-resistant and medium maturing breeding nurseries at IITA.

Table 5-2: Number of improved cowpea breeding lines tested across countries

	In country developed breeding lines	IITA developed lines	Total
Mali - IER	5	43	48
Mozambique - IITA & IIAM	3	16	19
Niger - INRAN	11	25	36
Nigeria - IAR	20	48	68
Tanzania - ARI	4	16	20
IITA - Kano	-	78[1]	78

The listed 16 breeding lines were tested in Mozambique and Tanzania in the cropping season of 2007-2008. The protocol for carrying out the trials was agreed at the project's launching meeting in Arusha and fine tuned during annual sub-regional meetings held each year.

Protocol for evaluating the breeding lines under terminal drought (agreed on by all)

- Scientist managed
- Farmers to visit sites in order to select preferred lines by them
- Large plot sizes 20 x 20 meters
- Two dates of planting to enable plants in the second planting experience terminal drought
- Plant protection practices as done on-station
- Spacing between and within rows
- Land preparation
- Data to be collected
- Names/identities of existing lines to be included in each country

After three years of evaluations involving farmers' participation, the cowpea line IT97K-499-35 was selected by farmers in Nigeria and Mali for its drought tolerance and Striga resistance in Mali.

Cowpea line IT97K-499-38 was selected in Niger for its good performance. In East Africa, the cowpea lines IT00K-1263 and IT99K-1122 were selected by farmers in Tanzania for their drought tolerance and earliness (IT99K-1122) while IT00K-1263 was the preferred line by farmers in Mozambique.

Table 5-3: Cowpea breeding lines selected through PVS

Mali	IT93K-876-30; Kougnekou; Mbrawa; IT97K-499-35
Niger	IT96D-610;IT97K-499-35; IT97K-499-38; IT99K-573-1-1; Et DD 07
Nigeria	IT96D-610; IAR-06-1050; IT97K-499-35; IAR-00-1074 (Borno); IT99K-7-21-2-2; IT99K-216-24-2 (Kano)
Mozambique	IT18; IT00K-1263; IT97K-1089-6; IT16, IT98K-390-2, IT98K-131-2, IT98K-128-3
Tanzania	IT00K-1263; IT99K-1122; Vuli-1; Vuli-2; Fahari; Tumaini

Number of demonstration plots in each country

Between eight and 10 trials were established in each country every year. Sizes of demonstration plots were 20 x 20 meters. At least two lines (an improved and farmer's own) planted twice in the season. The second planting which was carried out usually two to three weeks after first planting was to ensure the plants in the second planting date experience terminal drought (Figure 5-5).

Figure 5-5: Farmers in a demonstration plot with two cowpea lines planted on two different dates in Mali in 2010.

Number of farmers involved in PVS

Project scientists and extension agents interacted with farmers in several communities in the five countries. The farmers were intimated with the procedures for PVS which they accepted with enthusiasm. The farmers also willingly allowed that parts of their farm land be used for demonstrations. A total of 1,892 farmers participated in the PVS in Mali, Niger, Nigeria, Mozambique and Tanzania. Seven hundred and thirty four of these were women representing almost 39% of all the farmers involved in PVS.

Cowpea varieties released

The project facilitated the process of crop variety release in some countries. In Mali, Niger and Nigeria 11 new cowpea varieties (Table 5-5) were released officially during this first phase of TL II. A few more lines are in the pipe line and depending on their performance many of them will be released especially since farmers are familiar with these varieties as a result of their involvement in identifying them in the fields.

Tanzania

Two promising lines – IT00K-1263 and IT99K-1122 – have been selected following PVS in 2009/2010 and entered into the national performance trial of 2010/2011. Information on DUS has also been submitted to the Tanzania Seed Certifying Institute for verification prior to their being released for planting by farmers in the country.

Table 5-4: Number of farmers involved in PVS (2007-2010)

Year	Country/Location	Men	Women	Total
Mali				
2008	Mali	30	10	40
2009	Mali	50	30	80
2010	Mali	85	35	120
Sub-total		**165**	**75**	**240**
Niger				
2008	Madarounfa	15	10	25
	Guidan Roumji	0	3	3
	Miriah	9	0	9
	Tanout	3	6	9
	Magaria	25	10	35
2009	Guidan Roumji	3	0	3
	Magaria	3	2	5
	Bandé	4	1	5
2010	Guidan Roumji	0	12	12
	Magaria	10	2	12
	Bandé	9	1	10
Sub-total		**81**	**47**	**128**
Nigeria				
2008	Kano	110	34	144
2009	Kano	128	23	151
2010	Kano	135	34	169
Sub-total		**373**	**91**	**464**
Mozambique				
2008	Rapale†	21	16	37
2009	Angoche	37	34	71
2009	Meconta	10	5	15
2009	Mogovolas	19	41	60
2009	Monapo	27	12	39
2009	Muecate	24	22	46
2009	Rapale	79	35	114
2010	Ancoche	60	52	112
2010	Meconta	22	92	114
2010	Monapo	43	3	46
2010	Nacaroa	30	2	32
2010	Namapa	1	0	1
2010	Rapale	46	20	66
Sub-total		**419**	**334**	**753**
Tanzania				
2008	Ismani	11	9	20
2008	Hombolo	12	8	20
2009	Iringa	45	86	131
2009	Dodoma	37	71	108
2010	Ilonga	15	13	28
Sub-total		**120**	**187**	**307**
Grand-total		**1,158**	**734**	**1,892**

†On-station PVS at Nampula

Mozambique

Many farmers have shown keen interest in several lines including IT00K-1263, IT97K-1069-6 and IT16 because of their yield performance, drought tolerance, grain color and size. These lines are early maturing and dual purpose producing more leaves which farmers are able to pick and consume before pods are harvested. In 2011, three varieties: IT-16, IT00K-1263 and IT97K-1069-6 were released in Mozambique.

Table 5-5: Cowpea varieties released in different countries

Variety code	Local name	Year released	Country	Location	Average on-farm yield Kg/ha	Yield advantage over check (%)
IT97K-499-35	SAMPEA-10	Dec. 2008	Nigeria	Northern guinea/Sudan Savanna region	835	60
IT89KD-288	SAMPEA-11	Dec. 2009	Nigeria	Northern guinea/Sudan Savanna region	800	56
IT89KD-391	SAMPEA-12	Dec. 2009	Nigeria	Savanna region	900	71
IT97K-499-35	Jiguiya	Oct 2010	Mali	Sahelian Zone (Mopti and Ségou)	1.000	70
IT93K-876-30	Fakson	Oct 2010	Mali	Sahelian Zone (Mopti and Ségou)	1.500	80
CZ1-94-23-1	Gana Shoba	Mar 2009	Mali	Sahelian Zone (Mopti and Ségou)	1.500	65
CZ11-94-5C	Cinzana Telimani	Mar 2009	Mali	Sahelian Zone (Mopti and Ségou)	1.000	60
IT97K-499-35	IT	2009	Niger	Maradi and Zinder	800	300
IT97K-499-38	IT	2009	Niger	Maradi and Zinder	700	200
IT98K-205-8	IT	2009	Niger	Maradi, Zinder and Dosso	800	300
IT99K-573-1-1	IT	2010	Niger	Maradi	500	100
IT82E-16 (IT-16)		2011	-	-	650	100
IT00K-1263 (IT-1263)		2011	-	-	800	150
IT97K-1069-6 (IT-1069)		2011	-	-	800	150

G x E analysis

The yield data obtained from the 16 improved breeding lines that were tested in all five countries were subjected to GGE biplot analysis. Data from Tanzania were not included in the final analysis due to some discrepancies in yield values. The results of the GGE biplot analysis showed the lines that performed relatively well in some environments compared with others. It also identified locations best suited for cowpea production. According to the analysis, seven genotypes, namely IT97K-1069-6, IT89KD-288, IT98K-166-4, IT97K-819-118, IT96D-610, IT98K-491-4 and IT99K-216-24-2 were the most responsive to the environments. Following a comparison of genotypes with an 'ideal' one, it was observed that IT98K-128-3, IT98K-311-8-2 and IT98K-626 were most desirable as they were closest to the ideal.

The best lines as identified by the analysis for certain locations were not necessarily the same as those selected by farmers at those locations. Other attributes than yield were taken into consideration while lines were being selected. It is interesting to note that farmers in Tanzania and Mozambique selected

IT00K-1263 because of its performance while in West Africa farmers in parts of Nigeria, Niger and Mali selected IT97K-499-35 because of its performance and Striga resistance.

Support for nationally coordinated cowpea trials in Nigeria

In Nigeria, TL II supported the nationally coordinated cowpea trials during 2010. Any crop variety that will be released in the country must go through a nationally coordinated research for the crop. Based on the line's performance across locations and years, it could be recommended for release. Data collected from these trials will be used to prepare the dossiers that accompany the lines being nominated by the breeders for release. Tables 5-5 and 5-6 show the performances, in terms of grain yield and Striga resistance of some breeding lines that were evaluated nationally in year 2010. These were further evaluated in 2011 and some of them qualified for release when presented to the national committee for crop variety release in the country in December 2011.

Table 5-6: Grain yield (kg per ha) of cowpea varieties in the short duration Nationally Coordinated trial at seven locations in Nigeria in 2010.

	Location							
Genotype	Abeokuta	Ibadan	Kano	Makurdi	Sabongari	Samaru	Tilla	Mean
IT99K-573-1-1	1205	365	2145	2162	1420	1457	810	1366
IT99K-573-2-1	1157	291	1640	1955	1210	1615	729	1228
IT04K-332-1	1186	211	2049	2258	1048	1180	559	1213
IT04K-333-2	1029	253	1933	2222	1092	1148	741	1202
IT97K-499-35	1152	300	2202	2227	1161	909	373	1189
IT98K-506-1	1099	312	1139	2129	1006	1363	601	1093
IT99K-1060	542	235	1956	2326	1338	700	444	1077
IT96D-610	1334	539	607	1941	1100	998	596	1017
IT99K-491-7	1035	271	1660	1685	1141	843	308	992
IT97K-568-18	647	278	1430	1464	1036	537	438	833
Mean	1039	306	1676	2037	1155	1075	560	1121
Probability	0.2370	0.4262	0.0037	0.0096	0.1370	0.0179	0.2135	<0.0001
SE	208.0	89.4	240.0	146.0	99.8	192.3	136.1	63.2
Cv (%)	34.7	50.7	24.8	12.4	15.0	31.0	42.1	25.8
G x E(SE)	167.2							
G x E (prob.)	<.0001							

Seed multiplication

Seed of the lines selected under the PVS was multiplied and used for on-farm trials across several locations in each country. Table 5- 8 shows the quantity of seed produced for each improved and farmer preferred line in Nigeria and distributed to farmers for planting in demonstration plots. In addition, seeds of some of the lines that were recommended for release were multiplied and submitted as required by the variety the release committee.

Table 5-7: Number of days to flowering and maturity, number of *Striga* and *Alectra* and 100-seed weight of cowpea varieties in the medium duration Nationally Coordinated trial averaged across seven locations in Nigeria in 2010.

Genotype	Days to flowering	Days to maturity	Number of Striga per plot	Number of Alectra per plot	100 seed wt (g)
IAR-00-1006	53	78	14	23	14
IAR-06-1035	55	79	17	15	13
IAR-06-1060	50	74	39	36	15
IAR-07-1050	49	75	1	1	12
IFE-20-14	48	72	26	19	16
IFE-98-12	48	74	41	39	15
IFOB/01/94/B	48	71	23	27	13
IFOB/99/94/DW	47	72	17	27	11
IFOBLDEGH/01	50	76	-	0	15
IT04K-221-1	48	71	25	19	14
IT04K-227-4	47	69	0	0	14
IT04K-321-2	49	72	11	10	14
IT89KD-288	57	79	2	6	15
IT97K-568-18	50	74	17	19	14
IT98D-1399	49	72	17	23	13
IT98K-131-2	50	73	13	12	14
IT99K-216-24-2	55	80	7	7	16
LDP08-OBLW	50	75		9	14
LDP10-OBR1	47	73	50	35	14
Local-Check	54	83	85	21	14
MODUPE	52	75	44	41	12
Mean	50	74	23	19	14
SE	0.4	0.6	10.3	8.2	0.4
PROB	<.0001	<.0001	0.0002	0.0097	<.0001
Cv%	3.7	3.5	77.9	103.5	11.4
G x E (SE)	1.1	1.5		11.6	0.9

Table 5-8: Breeder's Seed production Nigeria - IAR 2010

Variety	**Seed (Kg)**
IT00K-1263	40
IT99K-216-24-2	45
IT99K-7-21-2-2.	51
IAR-00-1074	110
IT97K-819-118	23
IT96D-610	31
IAR-1050	67
IT97K-499-35	68
Total	**435**

Mali - IER

From September 2010 to February 2011, 480 kg of Foundation Seed of the variety IT97K-499-35 "Hope" was produced at Cinzana Research Station. Also, seed farmers produced 235 kg of Certified Seed of "Hope" at San in Segou region. Seventy kg Foundation Seed of the variety IT89KD-876-30 was produced at Cinzana Research Station. In the millennium village, seed farmers produced 1,800 kg of Certified Seed of IT89KD-876-30.

Mozambique

Table 5-9a: Quantities (kg) of good quality cowpea seed produced at three locations in Mozambique in 2010

Genotype	Location			
	Nampula	Namialo	Sussundenga	Total
IT-18	700	520	650	1,870
IT00K-126-3	500	150	300	950
IT97K-1069-6	400	250	140	790
IT-16	950	720	-	1,670
IT98K-390-2	150	140	-	290
Total	2,700	1,780	1,090	5,570

Tanzania

Table 5-9b: Quantities (kg) of seed of the selected lines multiplied by participating farmers in Tanzania, 2010

Cowpea line	Iringa	Dodoma	Bahi	Kongwa	Total
	Uhominyi	Mpunguzi	Ilindi	Mbande	
IT00K-1263	70	220	857	40	1187
IT99K-1122	90	-	1040	20	1150

Evaluation of breeding lines for resistance to bacterial blight and viruses

All the cowpea lines which seeds were multiplied and shared with NARS colleagues were tested in order to ascertain their resistance to bacterial blight and viruses in the greenhouse at Ibadan. The results showed that some of the lines are resistant to bacterial blight as well as virus diseases (see Table 5-10). Thirteen of the 50 breeding lines from IITA which included IT00K-1263, IT99K-1060, IT99K-1122 and IT99K-1111-1 were highly resistant to bacterial blight, an important cowpea disease. The local line Danila which is drought tolerant also showed high level of resistance to the disease.

Table 5-10: Responses of some improved cowpea breeding lines to *Cowpea aphid-borne mosaic virus; (CABMV), Cowpea mild mottle virus (CPMMV)* and *Cowpea mottle virus (CPMoV)*

	*Genotype response to:		
Genotype	CPMoV	CABMV	CPMMV
IT98K-133-1-1 Early	R	R	R
IT99K-1122 Early	R	HS	R
IT98K-390-2 Striga	R	MR	R
IT98K-1092-1 Striga	R	MR	R
IT97K-1069-6 Medium	R	MR	R
IT04K-405-5 Dual	R	R	MR
IT00K-901-5 Early	MR	MR	R
IT98K-412-13 Dual	MR	MR	R
IT97K-819-118 Striga	MR	S	MR
IT99K-1060 Early	S	MR	MR
IT99K-573-1-1 Striga	R	R	R

**R = resistant (symptom score 0 to 1); MR = moderately resistant (symptom score 2); S = susceptible (symptom score 4); HS = highly susceptible (symptom score 5)*

Evaluation for phosphorus-use efficiency

Greenhouse potted soil (a mixture of subsoil and acid-washed sand) experiment was conducted to evaluate variation in phosphorus use and response efficiency. Nodulation generally varied among genotypes and so was the response to phosphorus application. Nodulation was highest in dual purpose lines such as IT98K-166-44 but response to phosphorus application was higher in IT89KD-288 than IT98K-166-44. There were highly significant ($P \leq 0.001$) genotype, phosphorus and genotype phosphorus effects on the utilization of P for shoot development. The genotype IT89KD-288 was the most efficient and IT99K-7-21-2-2 was the least under low phosphorus conditions. Among the early maturing lines, IT03K-351-1 formed the largest nodular tissue under low phosphorus conditions and depended least on higher soil available phosphorus for nodule formation and development. In the other genotypes however, nodulation was relatively low under low phosphorus conditions but the increase in nodule mass development in response to the high soil available phosphorus ranged from 83 to 515%. Genotypic differences in phosphorus utilization under both low and high phosphorus conditions were not extensive ($P \leq 0.05$) even though IT00K-1263 appeared to have performed better under low phosphorus conditions than most genotypes within the early maturity group.

Screening of germplasm lines for drought tolerance

Over 1,200 cowpea accessions among the germplasm maintained at IITA were randomly selected and screened for drought tolerance in the field. The screening was carried out during the dry season. Drought stress was imposed by withdrawing irrigation at five weeks after sowing while none stressed plots were irrigated until plants matured. Data were collected on number of days to flower, extent of wilting, and number of days to maturity as well as mean seed weight and total seed weight per plant (see Figures 5-6 and 5-7). Most plants flowered and matured earlier when drought stressed. Drought stressed plants also produced lower grain yield per plant. Many of the germplasm lines remained green even at seven weeks of no irrigation. However, a few of these plants did not flower and therefore produced no seeds but remained green and stunted.

About 190 accessions with enhanced drought tolerance were identified from this screening activity. These selected lines were further evaluated in pots placed in the screen house. Drought was imposed on the potted plants from three weeks after sowing and those that survived for more than four weeks thereafter were regarded as being most drought tolerant. Some of these lines were selected and used in making crosses among them and between them and some farmer-preferred varieties.

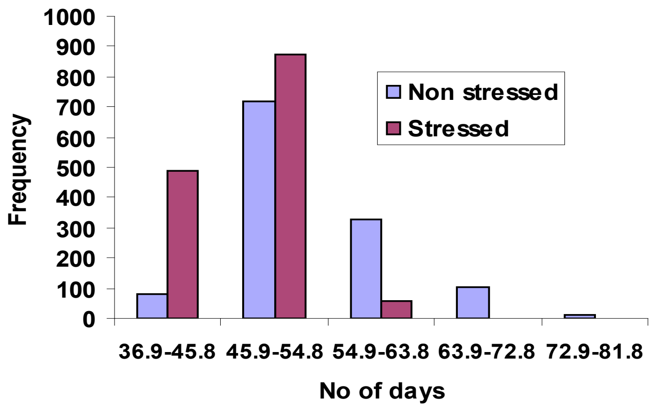


Figure 5-6: Number of days to flowering

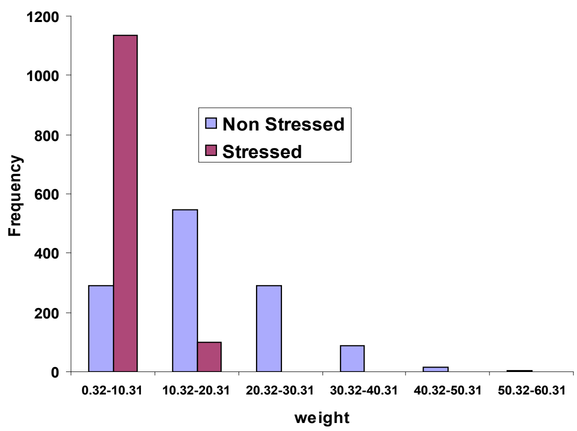


Figure 5-7: Seed weight (g) per plant

Making crosses and developing segregating populations

The best of the germplasm lines in terms of enhanced drought tolerance were crossed to one another and also to improved breeding lines that farmers had selected during PVS. There were over 200 cross combinations comprising single crosses, three way crosses and double crosses. These have been advanced to F8, F7, F6 and F5 generations, depending on when the crosses were made. Additional crosses have been made using lines obtained from our collaborating NARS breeders' nurseries. Selection will be made from these segregating populations for plants with superior drought tolerance and also possessing traits desired by farmers and consumers.

Number of crosses made and advanced

Single crosses	=	38
Three way crosses	=	83
Double cross	=	85
Crosses with lines from IER and INRAN	=	17 (In F3 and F4 generations)

Screening for resistance to aphids

The cowpea aphid (Aphis craccivora) is a major pest of cowpea, especially at the seedling stage and particularly when there is drought. A combination of aphid attack and drought could have very devastating effects on cowpea seedlings in the field. Many of the varieties that were developed with resistance to this pest now succumb to it. We have screened a number of cowpea germplasm lines but found very low levels of resistance among them. Wild cowpea relatives were also screened for resistance to this pest and about three of them that are cross compatible with cowpea were detected with moderate to good levels of resistance to aphid (Figure 5-8). Efforts are on to introgress the resistance genes into some FPVs.

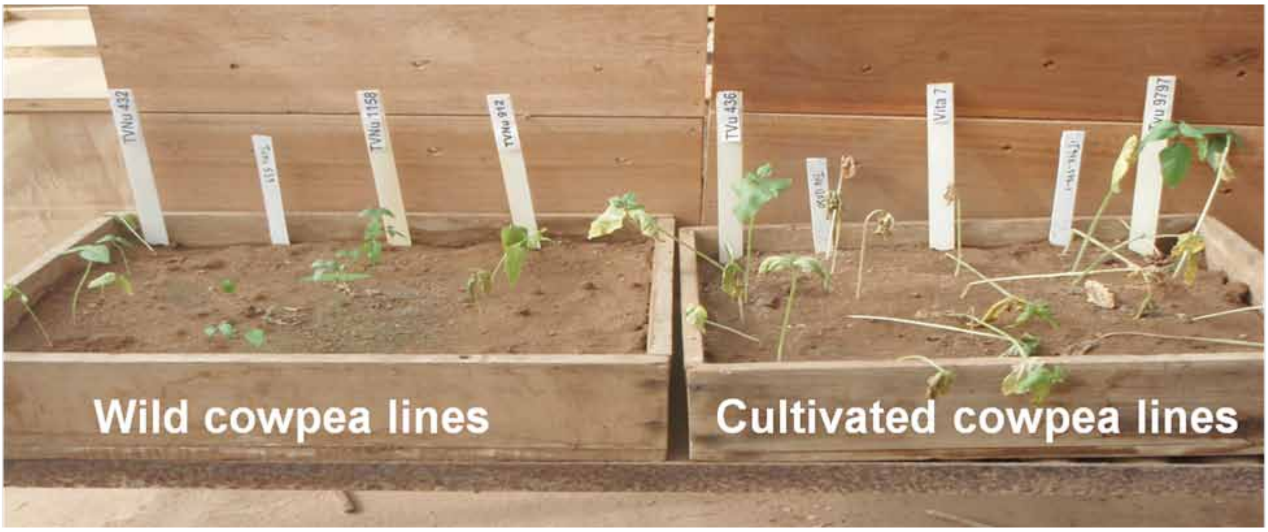


Figure 5-8: Reactions of some cultivated and wild cowpea seedlings to aphid infestation

Seedlings of the cultivated cowpea lines have collapsed following aphid damage while those of some of the wild cowpea relatives did not show evidence of aphid damage.

Validation of molecular markers

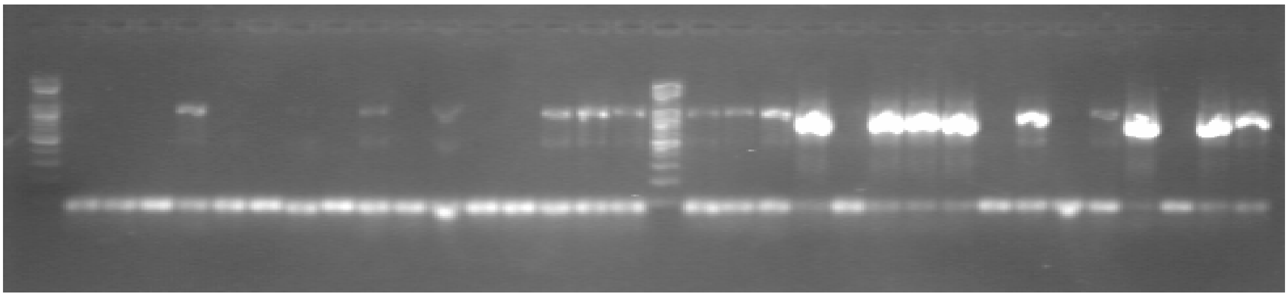
Cowpea SNP Marker Validation: As part of the collaboration between TL I and TL II some molecular markers found to be associated with desirable traits in cowpea at UC Riverside were validated at the IITA facility, at BECA in Nairobi. Allele-specific primers were designed to capture SNPs linked to important traits like SUR, Striga, Macrophomina/*CPMVnewb, Macrophomina, Gy-1, Gs-4, Gs-2, Flow-5, Flow-1/2, Drought, DLS-5/6, DLS-4,DLS-3, DLS-1/2, CoBB-3, CoBB-2/DLS-4, CoBB-2, CoBB-1/CPMVnewb, CoBB-1, Dehydrin, CPSMV and CPMVnewb. The SNPs were mined from the HarvEST:Cowpea v1.18 software which is a principally EST database. In order to design AS-PCR primer of extra 3′ mismatch, WebSNAPER (http://ausubellab.mgh.harvard.edu/) was used. Primers without extra 3′ mismatch were designed by use of DNASTAR Lagergene Software (www.dnastar.com/). PCR was performed using AccuPower® PCR PreMix (www.bioneer.com). Total of 10 SNPs appeared as reliable plus/minus scoring on agarose gel of the PCR products (Table 5- 11). These are the SNPs, converted to the agarose gel assay format and utilized to test 32 samples from a cowpea breeding population at IITA.

Table 5-11: Ten SNPs converted and used for the validation

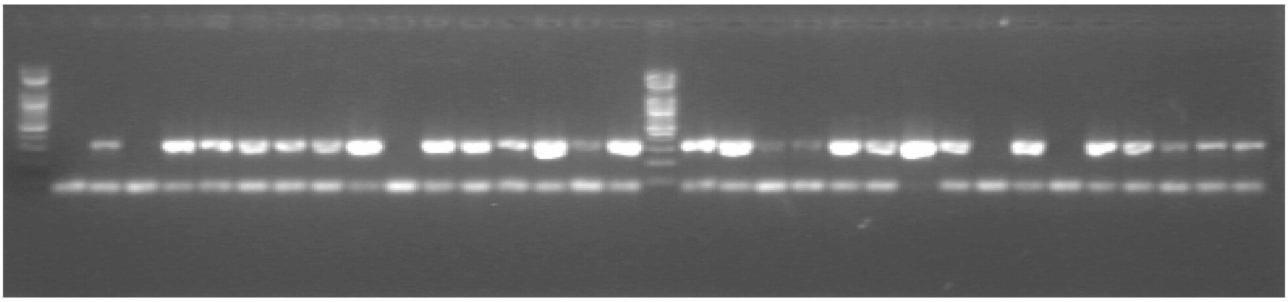
Primer	CHR	Posn (cM)	Trait	SNP Name	Primer
AS36	LG_03	1.3	CoBB-1	UP12_4270_135	F-CCTCTTCGCAGCCGCATTATCTCT R-CGTGCCGCTCGTGCCATAGTC
ASS6	LG_03	0	CoBB-1/ *CPMVnewb	UP12_12905_686	F-CTGGACACAGTGGGTATGTGAACACTGAC R-ATAACCACTAAACAAAGTGCTTCCATCTGCACT
ASS93	LG_03	72.4	DLS-1/2	UP12_17547_561	F-CCAAACTTGGGGCTCGTCTCAGC R-TGTCAATGATGATCTTCCTCCCGGTC
ASS16	LG_03	1.9	Macrophomina	UP12_9955_544	R-AGAAGAGTGGAAGCGGCGATGGAT F-ATGACTCTTCTCTCAAATATTGAGAAGTTCATTTCT
ASS64	LG_03	38.7	SUR	UP12_13864_1798	F-TCACTCCGTTCCTAAGGTTCGGCC R-TTTACCGTTACAAACAAACACAAGCTCCTTAGTG
ASS39	LG_07	15.8	Drought	UP12_998_587	F-GAGAAAAGCTTAATTAAACCGAAACAGGCG R-AGAAGAAGACCTATACCAAGCCTAAGAAGATCAAGC
AS100	LG_08	0	Drought	UP12_14702_888	F-CCGCCTAGAGTTCCACGCTTATCG R-GTGGTGTGTTAGGTTGTGAGAGGAAGAGTGA
ASS110	LG_08	22.9	Gy-1	UP12_5650_935	F-TGCAATGTTAGTGGCATTGTACTGGGG R-TAAACCATGCTAAGAATGGCGTCGACA
ASS130/ AS113	LG_09	7.3	CoBB-3	UP12_5698_563	F-ATCAAGTAAACAAAACAAAAACAGCCAGAATATATG R-CTCAGAAGCACCCAAATACAAGCTCATCA
ASS133	LG_10	39	Striga	UP12_12584_1346	F-TTGTAGCTGCTATTTTAAGAAAGCTAACAACCTCC F-CATGAATTGGAGCCAACTAAAACAACCAAA

Marker validation: In this study the feasibility of applying the designed SNP markers with 32 samples from a cowpea breeding population were tested. All the AS-PCR primer sets selected were optimized and validated. Ten SNPs, potentially linked to CoBB-1,*CPMVnewb, DLS-1/2, Macrophomina, SUR, Drought, Gy-1, CoBB-3 and Striga were converted to agarose gel assay. Information about SNP genotype was provided by the presence (scored as 1) or absence (scored as 0) of the PCR amplification product from allele specific primers (Figure 5, Table 9)

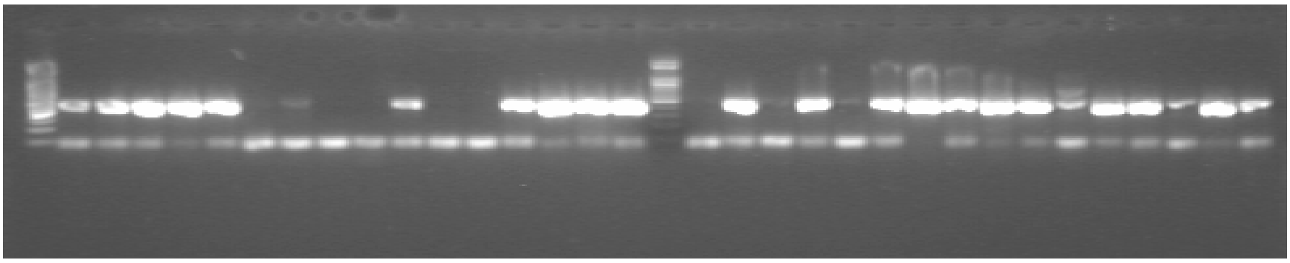
ASS6



ASS64



ASS110



ASS56

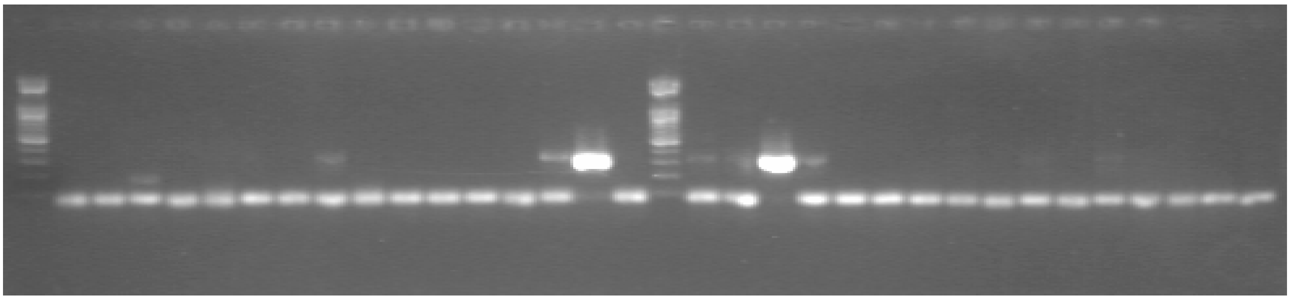


Figure 5-9: Examples of AS-PCR mapping results

The identified SNPs from cowpea ESTs linked to important traits have been converted into genetic markers. The converted SNPs are covering several regions of the cowpea genetic map, LG 3 (0 ~ 1.3cM), LG 7 (13~17.8 cM), LG8 (0~1.3cM), LG9 (3.4~7.3cM), and LG10 (40.8~41.7cM), where genes for several important traits may be present. Allele specific PCR primers (AS-PCR) were designed and tested with a cowpea breeding population. Out of the 57 SNP targeted using mismatch approach, amplification for 10 SNP were found to give robust AS-PCR, which is a good success rate for the marker development. Allele specific amplification was observed for at least one of the two alternative alleles at these SNP sites. In this study we found AS-PCR to be an efficient, cost effective and reliable way for SNP validation. Earlier studies in barley also revealed efficient validation of SNPs by allele specific PCR.

Strengthening capacity of national agricultural research systems scientists

Degree-related and short term training activities were carried out during the first phase of TL II. Students from the five countries were trained or their training supported (as in Mali and Niger below) by the project. The project trained two students from Mozambique at MSc level in plant breeding at Bunda College of Agriculture, Malawi. The project paid fully for the students' training in a different country than theirs. In addition, some technical staff received training in the field on screening for drought tolerance in crops. Farmers also participated in one day workshops where the protocol for PVS was discussed and agreed (Table 5-12).

Training of graduate students in plant breeding

Mali:- Siaka Dembele – Screening for virus resistance in cowpea
Niger:- Abdou Souleymane – Screening cowpea for aphid resistance

These two students are under the AGRA MSc program. Both are registered at the University of Ibadan and are conducting their research in cowpea breeding at IITA with funds from TL II.

Nigeria:

1. Auwalu Umar – Genetics of duration of cooking time. This student is to complete his study in June 2011;
2. Habibu Aliyu – Aphid resistance in cowpea. This student is to complete his study in August 2011;
3. Kayode Ogunsola – Genetics of resistance to some viruses in cowpea. A PhD degree program is still in progress.

Mozambique:- Two students from Mozambique were trained in plant breeding at MSc level at Bunda College, Malawi. They are:

1. John Bulassi Kaunda MSc (Breeding) returned to IIAM working on cowpeas in Lichinga, Niassa province
2. Henriques Victor Collial MSc (Breeding) returned to IIAM Nampula working on both Cowpea and Soybean.

Tanzania:- One MSc. Student, Mr. Didas Kimaro completed his research project in September, 2010. All the university fees and direct costs for student, including funds for his research have been paid by the TL II project.

Table 5-12: Number of farmers and technicians trained per country

Country	Number
Mali	100
Niger	369
Nigeria	3,500
Mozambique	1,659
Tanzania	469
Total	**6,097**

Workshops

Stakeholders meetings held each year at the Sub-regional level of WCA and ESA for cowpea and soybean. For WCA the meetings held in Niamey in 2008, Maradi in 2009 and Kano in 2010. All collaborators from the NARS, ADPs and NGOs such as SNV and Alheri Seeds in Niger were invited and participated actively in the meetings where activities in the previous year was reviewed and plans for coming season were fine tuned. There were also short duration (one day each) meetings with farmers' groups (Figures 5-10 and 5-11) where reports of experiences in the fields during previous cropping season were discussed.

Farmers who wished to participate in the PVS were also identified at such meetings.

Figure 5-10: Meeting of farmers' groups held at INRAN station at Maradi, Niger (December 2009)

Figure 5-11: A group of farmers being trained on techniques of participatory variety selection at Ilonga, Tanzania (26 October, 2010).

Infrastructure development at NARS

The project provided some assistance in improving irrigation facilities to participating national research institutions. This support enabled the breeders to carry out off season cowpea planting which made it possible to conduct phenotyping for drought tolerance, multiply seeds and also quicken the advancement of segregating generations. Planting during the dry season increased the number of generations that could be obtained each year thereby reducing the number of years needed for variety development and release.

The supports provided were:-
Mali: Support for irrigation at Cinzana station
Niger: Support for irrigation at INRAN Maradi
Nigeria: Upgrade of irrigation at Minjibir
Mozambique: Irrigation set up in Gurue in Zambesia
Tanzania: Fixing of water pump at ARI Ilonga station

Some outcomes

- At least two improved breeding lines were selected in each country with PVS. At may locations the selected lines performed better than farmers' varieties especially where drought occurred;
- Seeds of the selected lines have been multiplied and supplied to farmers for planting in demonstration plots;
- Crosses have been made between germplasm lines with enhanced levels of drought tolerance with improved breeding lines;
- A number of segregating populations are being advanced from where selections will be made for new lines with better drought tolerance and other traits; and
- Students from Mozambique, Nigeria and Tanzania have been trained in plant breeding at MSc level.

Recommendations for adoption of improved technologies

The following recommendations should enhance the development of effective policies for technology adoption:- i) emphasis be changed from demonstrating new technologies to one of facilitating farmers to test new technologies in their own environments; ii). gender mainstreaming in future project activities to facilitate participation by women which has the potential to influence their adoption of improved technologies; iii) community seed production should be encouraged and promoted to facilitate easy access to improved seeds; iv) policies should be designed to ensure that farmers have good access to fertilizers through adequate supply, and efficient distribution and v) policy, which provides adequately trained and equipped extension workers for disseminating extension messages to farmers should be promoted.

The best approach to spread the improved technologies to users

- The involvement of farmers, farmers groups and other stakeholders such as extension agents and NGOs help in getting developed technologies to where they would make necessary impacts.

NGO's, entrepreneurs and local Government officials were found helpful in pushing technologies to rural areas where most cowpea farmers are located;

- Increased participation in field days and farmers' visits to others' fields expose the farmers better to the available technologies. Such visits have positive influence on farmers and their willingness to take up new technologies which they see;
- Crop variety release process could be cumbersome in many countries. The project helped to facilitate the process by supporting meetings of variety release committees in the different countries; and
- Fostering stronger collaborations with sub-regional seeds initiatives such as WASA in West Africa.

Lessons learned

The proposed training in country of graduate students in plant breeding at MSc level would have to be modified. This is because scientists especially those in Franco-phone countries have requested that efforts be made to expose their graduate students to the English language during their training. They would like for their students to go to English speaking countries for the training. There are cost implications for the out of the country training of graduate students. We are in contact with the University of Ghana on how to get students from the countries trained in the university. At present TL II is supporting the research work in cowpea breeding of two students, one each from Mali and Niger, registered at the University of Ibadan and sponsored by AGRA.

Seed Production and Delivery Systems

Summary

The cowpea seed system delivery component of the Tropical Legumes II Project was carried out with the participation of five countries in Sub-Saharan Africa: Nigeria, Mali, Niger, Mozambique, and Tanzania. Baseline survey on the legume seed supply chain and other form of value-addition was carried out in all of these countries. The study confirmed that the formal seed systems as they exist were not providing sufficient quality seed of cowpea to meet the demands of farmers. For farmers to benefit from the new technologies, the public sector needs to work in close partnership with the private sector to improve seed systems ensuring also that small farmers are brought into the process. These findings were used to strategize work plan for the project. Knowledge of cowpea seed systems advanced significantly in the first phase of the project. Successes were registered in Nigeria, Niger, Mali and Mozambique in production and delivery system. The small pack strategy, developed in partnership with the private sector, was also very successful. Marketing seed in small quantities of 1 and 2 kg packs that are within the reach of smallholder farmers was found to be both profitable to a small private seed company and attractive to farmers.

The goal of the TL II seed component was to develop sustainable seed production and delivery systems that will reach the smallholder farmers in drought-prone areas of SSA through interventions designed to:

- Bring about significant increases in the productivity and production of cowpea;
- Facilitate production of Foundation Seed;
- Facilitate production of Certified Seed;
- Promote and strengthen seed/input marketing through linkages to private seed companies;
- Create awareness to popularize improved stress-tolerant cowpea varieties; and
- Capacity building to strengthen stakeholders.

By the completion of the first phase, TL II activities had directly trained and supported a total of 1089 community seed producers and linked to private seed companies. Of this total, 534 were from Nigeria, 114 from Niger, 189 from Mali, 121 from Mozambique, and 101 from Tanzania. The TL II project has demonstrated that community production of improved varieties can be successful, but its continued sustainability depends on development of successful seed associations, with links to the formal seed sector. Foundation Seed production figures showed that about 30.55 MT of Foundation

Seed of different cowpea varieties was produced in Nigeria, 15.02 MT in Niger, 22.868 MT in Mali, 8.4 MT in Tanzania, and 21.15 MT in Mozambique. To create demand, for the adoption and use of improved seed of cowpea in all the project countries, the project facilitated the production of Certified Seed by community-based seed producers. This activity resulted in cumulative production of over 493 MT of cowpea of Quality Assured/Certified Seed with most of the fields certified by the country seed certification agency in all the target countries over the 3 years period. Of these quantities, 231 MT of Certified Seeds of different cowpea varieties was produced in Nigeria, 103.4 MT in Niger, 35.03 MT

in Mali, 107.3 MT in Mozambique, and 2.3 MT in Tanzania. To popularize improved varieties through on-farm demonstrations, 796 lead farmers appointed by their groups were supported in Nigeria. The number of farmers that benefited in Niger, Mali and Mozambique was 339, 265 and 1775, respectively. In Nigeria, the average grain yield across locations of improved varieties was 1458 kg per ha compared to the local variety that was 863 kg per ha, representing about 69% yield increase over the local variety.

Improved market linkages have encouraged seed producers to improve and increase seed production to supply a growing market. Market development for cowpea resulted in increased production and sales of cowpeas, making significant contributions to improving livelihood and poverty reduction. Over 188 MT of seed was sold by seed producers in Nigeria, 31.5 MT in Mali, and 93.7 MT sold in Niger, within the first phase of the project. This market is now established paying good prices, a situation likely to be sustained.

Awareness creation was conducted through field days, demonstrations and mid-season farmer evaluation of improved varieties. A significant number of farmers, agro-dealers, extension staff, and policy makers have been exposed to TL II improved technologies. Over 12,000 farmers have been reached with small pack seed dissemination over the last 3 years to further popularize the improved cowpea varieties.
The project, having recognized the significance of capacity building of its partners to achieve its objectives, organized and facilitated capacity development activities for its partners, as well as , improving the infrastructure for carrying out effective research and development for NARS Capacities of the stakeholders have been strengthened through training and subsequent applications; participation in national and international scientific conferences and meetings; research opportunities for higher degrees based on TL II activities; as well as improved access to information and new knowledge.

Strengthening of community-based organizations, in particular the farmer groups and associations, through the use of Participatory Research and Extension Approach (PREA) and technical training in many aspects of agricultural production played a key role in sustaining project activities. Training and support for quality Certified and Foundation Seed production, reinforced with post harvest processing, storage, distribution and marketing ensured that quality seed of the new varieties was made available to other farmers. Extension materials, in particular cowpea production guides, prepared in English and French were distributed to farmers and other stakeholders.

Improving cowpea seed systems

Cowpea seed production in SSA has faced a series of constraints which affect its productivity and production, geographic scope and social reach of distribution. Public sector seed production has not been able to multiply large quantities of Foundation Seed—as priority for such foundation stocks is given to more commercial crops—such as hybrid maize. Further, when public sector does scale up, stocks are often diverted to emergency seed distribution, as cowpea seed is a favorite 'relief crop' of both governments and NGOs. The private seed industry also has not found the cowpea seed business lucrative, as once farmers get new varieties they tend to re-sow from their own saved seed for many seasons, instead of purchasing seed anew from certified sources.

The demand side has also faced a number of challenges - at the most fundamental level, many farmers simply do not know about new varieties (i.e. their potential advantages, where to access them, among others). Seed production often takes place in higher potential areas, with seed stores also being concentrated in zones of higher population density or those with better infrastructure (that is, not the stress areas). Further, when seed of promising varieties is made locally accessible, it tends to be too costly (in relation to seed from local markets) and/or sold in package sizes of interest only to the larger-scale farmers.

For all these reasons, cowpea seed systems need to be specifically designed to serve the needs of the smallholder and to reach those in remote and less favored areas. The TL II cowpea seed system component particularly focused on 1) decentralizing seed production in rural zones and 2) verifying dissemination and marketing strategies to reach all farmers, including women and those with limited financial means.

Improving access to Foundation and Certified/Quality-Assured Seed and strengthening the seed value chain

In the last three years, a total of 107.73 MT of Foundation Seed has been produced from various cowpea varieties in the project countries and sold to seed growers (Table 5-13). Table 5-13 shows that 26.8 MT was produced in 2008 with Mali, Niger and Mozambique exceeding the annual target of 5 MT per year. Nigeria produced 6.1 MT of the expected target of 10 MT per year. Similarly, Tanzania produced below the annual target of 5 MT per year. In subsequent years, all the countries produced in excess of the annual target except Tanzania and Nigeria that produced below the target in 2009 and 2010, respectively (Table 5-13).

Table 5-13: Quantity (MT) of cowpea Foundation Seed produced in target countries

Country	Year			Total
	2008	2009	2010	
Nigeria	6.10	10.00	14.45	30.55
Niger	5.00	6.40	3.62	15.02
Mali	5.70	8.76	8.40	22.86
Tanzania	3.50	3.40	10.90	17.80
Mozambique	6.50	8.50	6.50	21.50
Total	26.80	37.06	43.87	107.73

In terms of production and delivery approaches tested under Phase I included, four Certified Seed production models, two models of decentralized seed production and five seed delivery models were tested (Table 5-14).

Table 5-14: TL II cowpea seed systems, approaches tested under TL II

Certified seed production	Decentralized seed production	Delivery approaches
• Direct production- NARS • Direct production- NARS seed unit with contract farmers • Private seed companies • Farmer cooperatives	• District/government officers supporting individual farmers • NGOs supporting individual farmers • Farmer Cooperatives/Unions • Community-based seed production	• Small pack sales: open markets • Small pack sales: country stores • Small pack sales agro-dealers • Exchanged through seed loans • Direct farmer to farmer diffusion

Approaches tested

Seed production was monitored throughout the project cycle. NARS kept careful records of initial Certified Seed produced and distributed to partners, while selected partners in decentralized zones kept records of farmer multipliers, farmers receiving seed, and multiplication rates by region. Monitoring with individual farmers also provided data on how the individual harvest was used (e.g. whether eaten, stored, saved as seed, exchanged, and sold as seed or grain).

Certified Seed production figures

To ensure accessibility of seed of the improved crop varieties to farmers, the project introduced a community-based seed production scheme across the participating countries. Over the period 2008-2010, a total 496.58 MT of cowpea seed was produced. Table 5-15 shows the overall Certified Seed produced over the first phase of the project. Among the countries, only Nigeria produced in excess of the annual target for the three years. On the other hand, Tanzania and Mali produced below the annual target in each of the three years period (Table 5-15). However, the TL II project has demonstrated that community production of seed of improved varieties can be successful, but its continued sustainability depends on development of successful seed associations, with links to the formal seed sector.

Table 5-15: Quantity (MT) of cowpea Certified Seed produced in target countries

Country	Year			Total
	2008	2009	2010	
Nigeria	75.00	75.60	81.00	231.60
Niger	6.70	54.90	41.90	103.50
Mali	0.70	18.80	15.40	34.95
Tanzania	-	2.70	16.80	19.50
Mozambique	15.30	41.50	50.25	107.03
Total	97.70	193.5	205.35	496.58

Testing small packs

The use of small packs is based on the field insights that farmers want access to new varieties, and that some also are willing to pay for Certified Seed at affordable sizes. Seed simply has to be marketed in affordable sizes, in places which are easily accessible to farmers, and from vendors that farmers trust (or who may be held accountable to buyers). Available M+E data shows that 314 MT of seed was sold in small packs across three countries (with this quantity representing the minimum quantity sold, as a number of partners did not report back specific sales figures).

In Nigeria, the small seed pack approach was pioneered by Jirkur Seed Cooperative and the Premier Seed Company, especially across northeast and northwest Nigeria. Packs were sealed in 1 kg, 2.5 kg and 5 kg sizes and sold at 150, 400 and 600 Naira, respectively (1USD = 150). One M+E follow-up showed that the majority preferred the 2.5 kg pack, which they can afford with their domestic funds.

In Niger, packs were sold in the eastern and southern parts of the country through farmers' cooperatives unions, NGOs and in open market places. Given the very modest buying power of farmers in Niger- and important role of cowpeas - the lively interest in small cowpea packs was unexpected. At the beginning of the project, NARS and NGOs considered that farmers only wanted large quantities, that is, 50 kg and 20 kg packs. IER and SNV then moved to putting on offer 5 kg and 2 kg packs. Now, sales data have shown that many Niger farmers desire smaller amounts - even 500 g and 1 kg packs, particularly as they expand to new varieties. The same modules were adopted in Mali and Mozambique

Progress in on-farm demonstrations

Demonstration plots were established in all participating countries to popularize and showcase the performance of improved varieties to large number of farmers.

In Nigeria, 796 farmers (659 men and 137 women) successfully established on-farm cowpea demonstration plots spread across 41 communities in the project areas of Borno, Kano, and Benue states.

The average yield for the improved varieties was 1447 kg per ha, compared with 800 kg per ha obtained from the farmers' local variety. In 2010, 30 demonstration plots were established in Benue State. The average yield ranged from 1258 to 1684 kg per ha for the improved cowpea varieties compared with 1100 kg per ha that was obtained from the farmers' local variety. This result shows the high potential of cowpea in the zone.

In Niger Republic, a total of 339 farmers (329 men and 10 women) demonstration plots were established in Maradi and Zinder regions. The average yield for the improved varieties was 1085 kg per ha, compared to 700 kg per ha obtained from the farmers' local variety.

In Tanzania, 28 demonstrations plots were established in 6 villages in the study districts. In Mozambique, 1775 on-farm demonstration plots were established across 16 communities in Nampula province to popularize and promote promising IITA cowpea lines. In Mali, 265 demonstrations plots were established in the project areas where average yields of 800kg per ha was reported.

Progress in midseason evaluation and farmer field-days

As part of activities to popularize the improved varieties, farmer field days were held in all five countries to demonstrate to large numbers of farmers, other stakeholders and the general public the performances of the improved varieties available. Over 45 mid-season evaluations and field days were held in Nigeria over the three seasons. Feedback from the mid-season evaluations and field days was given to cowpea breeders to guide them in the breeding program. In Mali, 11 field days/mid-season evaluation was held.

Progress in seed dissemination

In order to enhance the adoption of improved cowpea varieties, large volumes of cowpea seed were distributed to farmers in small packs of 1 kg mini kits. A total of 8.83 MT of improved cowpea varieties were distributed to 5,790 farmers.

In Nigeria, about 6.33 MT of cowpea seed packaged in 1 kg packets were disseminated to over 4,885 (3,409 men and 1,476 women). This activity was aimed to accelerate the production of improved varieties of cowpea. The seeds were given to farmers as seed diffusion in project areas.

In Niger, 800 kg of different cowpea seeds were disseminated to farmers as mini kits of 1 kg or 500g. Over 1399 farmers from different districts benefitted from this activity.

In Mali, about 5 MT of seed was distributed to over 2,300 farmers in 1 kg packets.

In Mozambique, 1.05 MT of improved cowpea varieties was disseminated to over 545 farmers in different provinces.

Progress in market linkages

To ensure that seed producers have access to quality/assured Foundation Seeds and market outlet for the sales of their seeds, seed farmers were linked to institutions that have mandate for the crop and other major seed companies. The linkage was aimed to encourage the seed producers to improve and expand seed production as a result of the additional markets outlets

In Nigeria, a total of 188.9 MT of Certified Seeds of different cowpea varieties were sold over the last 3 seasons. Of this total, 100 MT was sold in 1, 2 and 10 kg packs to farmers. In Niger Republic, over 93 MT of improved cowpea varieties in small packs were sold through input dealer shops and cooperative stores. In Mali, a total of 31.58 MT of different cowpea seed has been sold over the last 3 seasons. In Mozambique, a total of 50 MTof Quality-Assured seed was sold to farmers.

Lessons learned

TL II cowpea seed systems Phase 1 lessons are listed below.

- Building a strong effective partnership for wide spread success: to deliver improved cowpea varieties and production technologies require diverse partners in addition to the usual National Agricultural Research Institutions;
- Complimentary crop management technologies: Complementary crop management practices that contribute to increased yield promoted alongside improved crop varieties are two components to increase productivity;
- Availability and access to foundation/Certified Seeds, Foundation Seed production remains solely in the hands of the NARS and access to new varieties and initial seed by seed companies or other seed producers remains limited. In addition, the numbers of community seed producers are limited. The schemes should be strengthened and linked to private seed companies. Collaboration with private seed companies should also be strengthened;
- A small pack marketing approach has the potential to reach hundreds of thousands of farmers, quickly. In both Nigeria and Niger, the sale of small packs has reached men and women farmers, and expanded the use of Certified Seed. It has also given farmers the opportunity to experiment new varieties - at minimum risk. The small-pack model has already spread to other crops; and
- Monitoring and evaluation have been crucial for understanding project opportunity and constraints. Considerable energy was expended to develop and put in place for the Integrated Performance Monitoring and Evaluation (IPME) processes of the project and such start-up efforts should not be underestimated. IPME has also delivered quickly—especially in identifying some of the opportunities and weakness of the project.

Enhancing Common Bean Productivity and Production in Sub-Saharan Africa

Stephen Beebe, Idupulapati Rao, Jose Polonia, Jaumer Ricaurte, Miguel Angel Grajales, Cesar Cajiao (CIAT-Colombia); Rowland Chirwa, Jean Claude Rubyogo (CIAT-Malawi); Paul Kimani (CIAT-Kenya); Enid Katungi), David Wozemba (CIAT-Uganda); Louise Sperling (CIAT-Tanzania); Setegn Gebeyehu, Teshale Assefa (EIAR-Melkassa, Ethiopia); David Karanja, David Macharia (KARI-Machakos, Kenya); Sosthenes Kweka, John Msaky, Elisa Mazuma (SARI-Tanzania); Godwill Makunde, Kennedy Simango (Zimbabwe)

Summary

The common bean component of the Tropical Legumes II Project was carried out with the participation of five countries in eastern and southern Africa (the same five countries of Tropical Legumes-I): Ethiopia, Kenya, Malawi, Tanzania, and Zimbabwe. The baseline and seed system components under Objectives 1 and 8 respectively, were centered on Ethiopia and Kenya. The baseline study confirmed many of the previous results of surveys with farmers regarding preferred traits (e.g., earliness, fast cooking, marketability) and low adoption status of improved varieties released 1990-2000s. It was nonetheless surprising that even in the most affected drought prone regions of Kenya, farmers continued to value the potential for market types (growing the commercial GLP 2), although they also cultivated the drought tolerant variety GLPx92 which has low market value. KAT B1 is another option for drought areas, given its extreme earliness. Superior lines were selected from a fast track nursery, initially composed of more than 1700 entries. The program in Kenya was especially successful, identifying lines with more than 50% yield advantage over elite checks and good farmer acceptability in on farm trials. Navy bean lines were selected in Ethiopia with 50% yield advantage over the elite check in managed drought stress trials, and with 12% advantage on farm in 2010 when rain was plentiful. Lines in Malawi advanced from a previous drought project express up to 50% advantage on farm and on station, and are near release. Selected lines in Tanzania and Zimbabwe are in the pipeline for release. Knowledge of bean seed systems advanced significantly in phase 1. Success was registered in both Kenya and Ethiopia with the small pack strategy, developed in partnership with the private sector. Marketing seed in small quantities that are within reach of smallholder farmers was found to be both profitable to a private company and attractive to farmers. Seed loans were practiced in Kenya with substantial success. It is estimated that well over a million farmers were reached with new varieties. This has resulted in on-farm increases in area share of 20-40% occupied by improved varieties in Ethiopia that were released in 1990s but remained on the shelf due to constraints to seed production and distribution at the time.

Introduction

From the outset of the TL II project, activities were closely coordinated with the network of the Pan-Africa Bean Research Alliance (PABRA), which coordinates bean research and development activities across 28 countries in eastern, southern, central and West Africa. PABRA is sub-divided into three regional networks: the Eastern and Central Africa Bean Research Network (ECABREN); the Southern Africa Bean Research Network (SABRN); and the West and Central Africa Bean Research Network (WECABREN). Five countries of the PABRA network were included as participants in the project (the same 5 countries that participate in the TL I project). These were: Ethiopia, Kenya, Malawi, Tanzania and Zimbabwe. One additional national program, Rwanda, participated in one training workshop with funds from another project. Results were presented in PABRA coordination meetings, such that partners throughout the region were made aware of the project and its results. Integration of TL II into the PABRA framework and regional networks will facilitate dissemination of results, and the incorporation of other partners into a Phase 2.

Phase I Social Sciences research in Objective 1 and Objective 8 focused on two countries: Kenya and Ethiopia. In Kenya, the project was spearheaded by the Kenya Agricultural Research Institute (KARI) and was implemented in the drought prone areas of Western Kenya along the Lake Basins (Nyanza and Western Provinces), Central and South Rift Valley (Rift Valley Province), dry land of Central Kenya (Central Kenya Province) and Lower Eastern Province (dry land of Ukambani). In Ethiopia, the project was led by the Ethiopian Institute of Agricultural Research-Melkassa, allied with the Southern Agricultural Research Institute (SARI) and implemented in southern Ethiopia, the Central Rift Valley, and drylands of the eastern and north eastern parts of the country.

During the course of Phase I, these areas were characterized by a series of stresses. In Kenya, this included political unrest (at the beginning of the project) followed by continuous severe droughts every season. In Ethiopia, the drought was mainly been severe in 2009. Also, both countries routinely receive substantial amounts of food and seed aid.

Socio-economic/Targeting

In Phase 1, baseline studies were carried out to inform the breeding and seed delivery components of the project for better targeting of impact and efficient allocation of resources, as well as provide a baseline against which project impacts would be measured. The analysis focused on understanding the current situation of common bean production and productivity, the constraints that hinder increased productivity, and the socio-cultural and economic environments that facilitate or constrain adoption of new technologies. Secondary time series data obtained from FAOSTAT and published reports were used to analyze the common bean production and yield trends in Eastern and Southern Africa. Primary data was gathered through a survey of randomly selected samples of farmers and traders along the value chains in two countries (Ethiopia and Kenya). The sampling frame was designed to support an impact evaluation that accounts for conditions "with" and "without" as well as "before" and "after" the project as part of an overall monitoring and evaluation framework. In each country, the population domain covers areas where common bean production is important but constrained by adverse climatic conditions, including domains that are purely commercial, semi-subsistence and largely subsistence. These three domains correspond to the Central Rift Valley of Ethiopia, the Southern Nations Nationality Peoples Regional State (SNNPR) of Ethiopia and the semi arid Eastern province of Kenya, respectively. A multi-stage sampling procedure was used to select the actual villages and households included in the survey.

Production and productivity trends

Common bean production in eastern and southern Africa is mostly extensive rather than intensive. FAO data shows that area under the crop has grown by 20% in the last two decades while yield growth rates have been largely negative (FAO, 2008). It was largely declining in most of the top producing countries throughout 1990s. Although yield growth rate remained negative in many parts of ESA, it has also been recovering in the last decade (Figure 1). During the 2000s, the growth rate experienced recovery, reversing the negative trend to positive growth in Rwanda and Malawi, though it is still negative in Uganda, Kenya, Burundi, DRC and Tanzania (Figure 6-1). This recovery is partly a result of the effort of genetic improvement as well as innovations in the seed delivery and crop management systems to address the production constraints (especially declining soil fertility, drought, pests and diseases) by NARS and CIAT-PABRA research.

Common bean production constraints

Both secondary and primary data confirmed drought, pests and diseases, long standing soil fertility decline and seed accessibility problems as key constraints currently limiting common bean productivity growth.

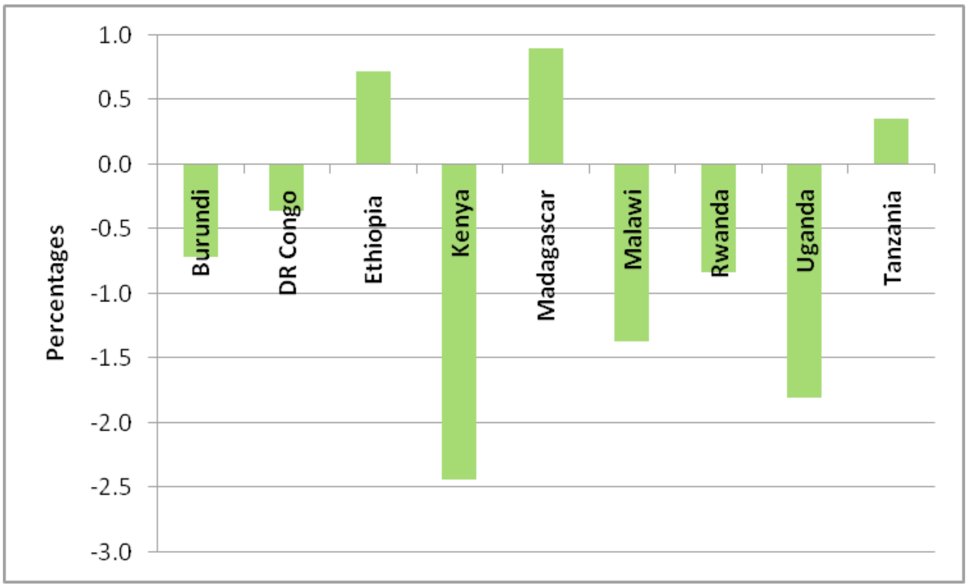


Figure 6-1: Annual rates of growth for common bean yields in selected countries, 1985-2007 (computed from FAOSTAT 2008)

Biophysical constraints

Drought is by far the most important common bean production constraint experienced by farmers in Ethiopia and Kenya (Table 6-1). The problem of drought interacts with other biophysical constraints such as declined soil fertility and pests and diseases to reduce yield growth. Estimates based on farmers' experiences with and without drought suggest that on average, each producer in Ethiopia expects to lose about 22% of annual harvest to drought while farmers in eastern Kenya expect to lose 43% of the total harvest. The problem of biophysical constraints, particularly drought, is further exacerbated by land- and labor-related problems. Average land holding is estimated at about 2.5 ha in the central rift valley of Ethiopia, about 1.7 ha in southern region of Ethiopia and about 1.7 ha in eastern Kenya (Table 6-2). These farmers grow a diversity of crops to manage the production risks (associated with drought, low access to non-farm income opportunities and credit assets [Table 6-2]), which in turn competes for the small landholdings and family labor. Small landholdings and crop diversification mean that use of traditional land fallowing can no longer be feasible. Future remedies should include land productivity enhancing agronomic practices such as use of inorganic and/or organic fertilizers and integrated pest and disease management options as integral elements of integrated crop management. Pest and disease constraints are ranked highly by farmers in both countries as directly limiting common bean production (Table 6-1) and indirectly as a source of risk that limits seed purchases, particularly in the Central Rift Valley of Ethiopia.

Seed accessibility problems

Poor access to seed of the desired variety is another important constraint limiting common bean production in Ethiopia and Kenya. The problem of seed accessibility manifests itself in several different but related forms that re-enforce each other. According to farmers in both countries, good quality seed is either not available in the farming communities, or when available, too expensive for small farmers to afford. At the time of the baseline study, farmers interested in acquiring new varieties had to travel an average of 15 km to reach the point of acquisition, evidence of large transaction cost given the limited means of transportation faced by these farmers. Problems on the demand side include high levels of poverty and risk aversion. In Kenya, some farmers explained that they cannot purchase seed because their soils are poor and yields will not support the extra costs. Furthermore, common bean is a self pollinated crop that can be recycled over several seasons, which means that demand for its seed cannot be easily predicted by the potential suppliers. Such uncertainty on the demand side implies that the private sector will always under invest in seed multiplication and distribution, causing market failures.

The consequences are that the improved varieties failing to reach the intended users at the time they are needed or high seed prices. Therefore, government interventions to support the initial seed production and distribution will be required at least in the short- to medium-term. The role of community level risk management schemes like crop insurance schemes also need to be studied and integrated in the interventions if found effective to reduce risk as a long-term strategy to encourage the growth of the private sector in input markets.

Table 6-1: Average weighted rank of the bean production constraints in Eastern Kenya and Ethiopia

Constraint	Eastern Kenya	Ethiopia	
		Central Rift Valley	SNNPR
Drought	4.83	5.43	4.18
Pests and diseases	4.07	4.27	3.85
Poor access to good quality seed	4.17	4.66	3.64
Low availability of good quality seed	2.17	2.47	1.85
High price of good quality seed	2.00	2.19	1.79
Lack of high yielding seed varieties	2.48	3.18	1.70
Land-related issues			
declined land sizes	3.51	3.04	4.03
Poor soil fertility	1.66	1.74	1.58
Labour-related problems	3.55	6.0	0.84
Shortage of labour	1.44	2.40	0.38
Labour intensive crop	0.63	1.17	0.03
High cost of labour	1.48	2.43	0.43
Others			
Lack of markets	1.45	2.22	0.61
Lack of good storage facilities	0.90	1.27	0.49
Lack of information	0.73	1.25	0.15

NB: The weighted average rank was found by multiplying each rank attached in decreasing order of importance by its weight corresponding to the importance. Weights were assigned to each rank in a descending order starting with 12 and ending with 1.

Table 6-2: Average total land size, utilization and contribution of non- farm income in eastern Kenya and Ethiopia

Parameter	Eastern Kenya (N=64)	Central Rift Valley* (N=115)	SNNPR* (N=105)
Average Landholding (ha)	1.680	2.680	1.700
Area allocated to the crops in a year			
Cropped area (ha)	1.140	2.510	1.620
Bean area (ha)	0.330	0.874	0.338
Crop area occupied by common bean (%)	28.900	34.870	22.320
% contribution of non-farm income to household cash income			
Petty trade	18.390	4.890	9.600
Formal off-farm employment	36.090	2.350	3.100
Remittances	17.470	-	-

**Data for only* meher *(main, long-rain) season was used for Ethiopian sample because common bean is rarely cultivated in the* belg *(short-rain) season*

Important variety traits to users

The research carried out in phase 1 also revealed that genetic improvement to address production constraints mentioned above will have to take place while meeting numerous users' preferred traits to facilitate significant adoption of varieties. Users (i.e. farmers, traders and consumers) along the value chains in both countries demand a diversity of variety traits. In Kenya, the top five demanded common bean traits by farmers across the regions are: better taste, early maturing, drought tolerance, high keeping quality and less cooking time. Some gender disparities were observed in ratings of variety attribute preferences in Kenya. Majority of women rated preference for drought tolerance, early maturing, tolerance to poor soils, better taste, and less cooking time higher than men. On the other hand, majority of men rated preference for grain color higher than women. Men and women rating of their preferences coincided for six traits: pest and disease resistance, high keeping quality, low flatulence and grain size. In Ethiopia, market traits (i.e. seed color, seed size and seed shape) stand out among the top five demanded traits. Seed color and shape are currently the key attributes used to grade bean grain for export by the export promotion council. Because of this new development, these two variety characteristics are expected to be even more influential in variety choice in the near future and could change the current adoption patterns. Other traits rated among the top five were high yield and better taste. It is surprising that even in areas dominated by the export canning type; better taste is a desired trait.

Supply of important traits by the improved varieties

Preferences analysis in phase 1 showed that improved varieties demonstrate a high potential of being adopted if seed is made available. They are rated superior to local ones in most of the top demanded traits by users. For example, three improved varieties (i.e. KATB1, KATB9, and KATX56) in Kenya are rated superior to the local popular variety in the top demanded consumption traits (taste, less cooking time and high keeping quality). The varieties also have an advantage over local ones in addressing terminal drought because they are early maturing. In Kenya, the very short cycle (and other qualities) of the Katumani bean varieties, has motivated farmers to plant three times in a single season, versus the normal one (for instance, in March, April and May)[1]. However, in terms of tolerance to intermittent drought, farmers do not perceive the three improved varieties to be different from the local variety, which could imply that they are equally vulnerable to this type of drought. Similarly, the majority of farmers in Ethiopia who have tried the improved varieties, released in 1990s and 2000s, on their farms expressed preference of these varieties over local ones (Mexican 142 or Chore). Among the farmers who planted the varieties in East Shewa and West Arsi, over 80% would choose Awash 1 over local ones while 60% would chose Awash-Melka over local varieties. This demonstrates overall superiority of improved varieties over local ones within the current production environment. These preferences are subject to change with changes in the production and market environment and should be constantly monitored to inform future crop improvement strategies.

Baseline status of adoption of improved varieties - 2008

Baseline survey data showed that a diversity of varieties exist at the community level in both Eastern Kenya and Ethiopia. About 15 varieties were identified in the sampled villages of each region, with the average number of varieties simultaneously grown per farm ranging from two in Eastern Kenya to 1.47 in the Central Rift Valley in Ethiopia and one in the SNNPR, which is consistent with the available information that common bean diversity is comparatively low in Ethiopia than in Eastern Kenya. Varieties most frequently grown by farmers (percentage of households) were the same as the most widely planted (percentage of total seed sown per season). In Eastern Kenya, about 74% of the common bean area in the main cropping season was found to be occupied by large red mottled varieties (GLPx92 and GLP2) released way back in early 1980s and/or landraces (Annex 6-1). In the Central Rift Valley of Ethiopia,

1 This strategy has resulted in three different harvests (via staggered planting), increased food availability and the spreading of risks in these unstable environments.

about half of area share of land allocated to common bean per farm was occupied by Mexican 142, released in 1972, grown by 64% of the households. Similarly, Red Wolaita, a cooking type released in 1974, occupied about 70% of the area under beans in SNNPR (Annex 6-1). The few dominating varieties were also the longest grown in the communities. The average number of years a variety was grown on a farm in Eastern Kenya ranged from 4 to 17 years, with few farmers maintaining the same variety longer than 30 years. In Ethiopia, the average number of years a bean variety had been grown ranged from 2 years to 12 years.

The adoption of the varieties released in early 1990s and 2000s in 2008 was still low, grown by 37.4% in Eastern Kenya, 42.6% in the central rift valley and only 7.6% in SNNPR (Table 6-3). In terms of area share, it was estimated at 11% in eastern Kenya, 44% in the central rift valley and about 12% in SNNPR (Table 6-3). Impediments to adoption of the improved varieties were cited as lack of information about the varieties and seed related problems already discussed in the previous sections.

Table 6-3: Use rates and area share of improved common bean varieties in the study area of Eastern Kenya and Ethiopia, 2008

Description	Eastern Kenya (N=123)	Central Rift Valley (N=115)	SNNPR (N=105)
	Percentage of farmers		
Improved varieties released 1990s-2000s	37.4	42.6	7.6
All Improved varieties	82.1	92.2	83.8
Landraces	88.6	1.7	12.4
	Percentage area share		
Improved varieties released 1990s-2000s	10.7	43. 9	12.5
All improved varieties	39.3	96.2	94.0
Land races	60.8	3.8	6.1

Variety adoption during phase 1 (2007-2011)

Following interventions to improve seed accessibility through scaling up/out of the seed multiplication and distribution activities under TL II (together with PABRA in 2007-2010[2]), positive changes were expected in terms of diffusion of information and variety uptake in both countries. In 2010, a structured monitoring and evaluation activity was implemented to assess early adoption so as to provide a feedback to researchers and policy makers. A total of 211 farmers randomly selected from the four production zones (East Shewa, West Arsi, Sidama and Western Haraghe) of Ethiopia were surveyed. In Kenya, the early adoption surveys were also conducted in five production regions (Nyanza, Western, and Lower Rift Valley, Central and Eastern Provinces of Kenya), involving 266 randomly selected households. In each country, villages in each district were selected with the help of the contact secondary partner in the area to represent locations that were exposed to the project and those that had not been directly exposed to the improved varieties by the project. To enable assessment of any changes in adoption of the improved varieties, a randomly selected sub-sample of the baseline sample was re-interviewed. A brief discussion of the key findings is presented in the next sections.

Ethiopia

Research findings revealed significant increases in information and seed diffusion among potential adopters. Over 60% of farmers were aware of the existence and superiority of the varieties by 2010. The overall analysis of the variety use across the whole sample in Ethiopia showed that four varieties (Awash

2 Note that, in both countries some of the varieties being promoted under TL II have been released for many years—but farmers just did not know them. In Kenya, the early-maturing, marketable Katumani varieties were released by KARI in the mid-1990s but, until 2008, were little known by farmers, except around the Katumani Research Center. In Ethiopia, some of the varieties which moved quickly under TL II, Awash 1, Awash-Melka and Nasir, were released in the early to late 1990s.

1, Awash-Melka, Nasir and Ibado) were gaining wide popularity among farmers and many farmers are simultaneously trying different varieties. About 60% of farmers planted at least one improved varieties for the first time during 2008-2010 (Figure 2), despite the fact that varieties had been in existence since 1990s. The rate of households growing the improved variety at least for the first time remained below 5% until 2006 when the number of households adopting increased to almost 10% and started growing at a rate of 5% in 2008/ 2009. This is largely attributed to the availability of seed of improved varieties in the farming communities and improved diffusion of information about the varieties during the project.

Per farmer average area under the improved varieties (i.e. Awash 1, Awash-Melka, Nasir and Ibado) has also increased during 2008-2009 in almost all production zones (Figure 6-3). Although the area planted to improved varieties in 2010 was disrupted by drought that caused yield loss in 2009, the overall patterns in the data suggest a trend in which improved varieties are rapidly replacing the varieties that were dominating the common bean area at the time of baseline surveys in 2008. The current challenge that threatens to slow down diffusion of some varieties is related with trader bias and climatic shocks. Traders usually mix varieties of the same color (white or red colors) to bulk the volumes needed by the buyers of their stocks. When the color differs slightly in brightness like that of Awash-Melka as compared to that of Awash 1 and Mexican 142, it becomes less attractive to traders since it will not meet their market requirements. Such varieties would be packaged and marketed alone but only when production meets the volumes required by the market. Market linkages strategies like collective marketing or corporate integration could be used to overcome such challenges.

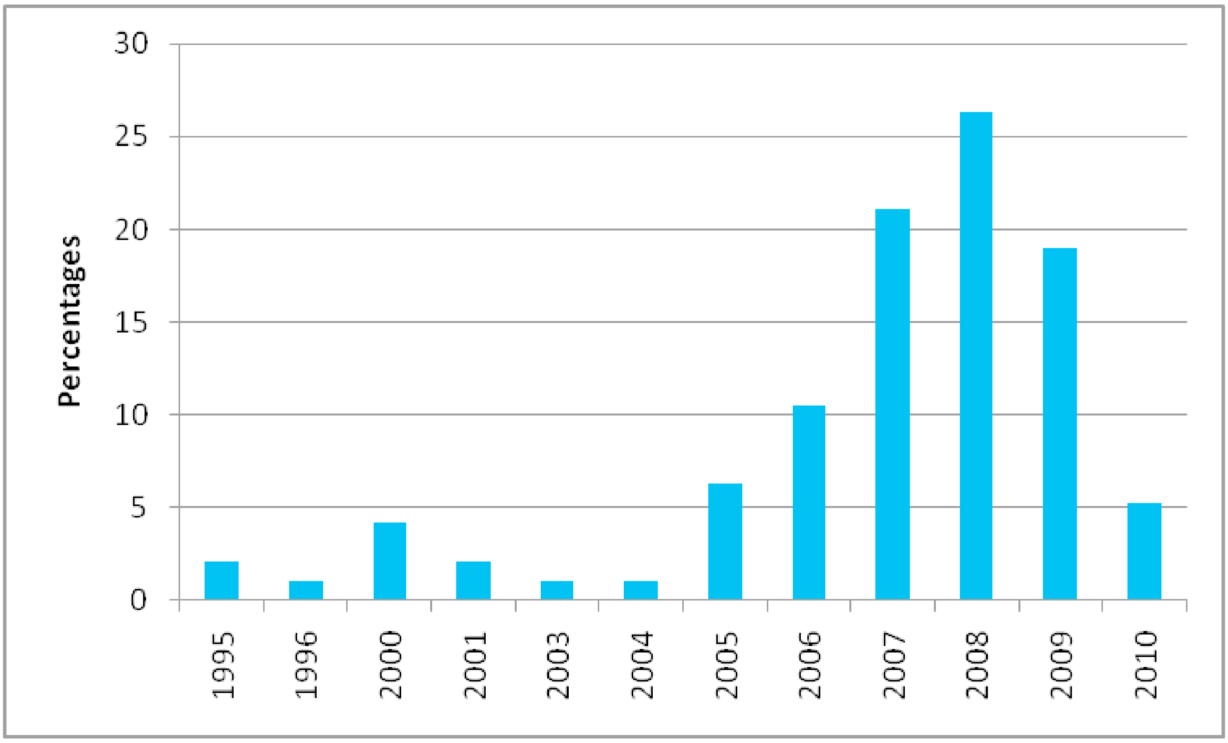


Figure 6-2: Percentages of households planting any improved variety for the first time in each year in Ethiopia

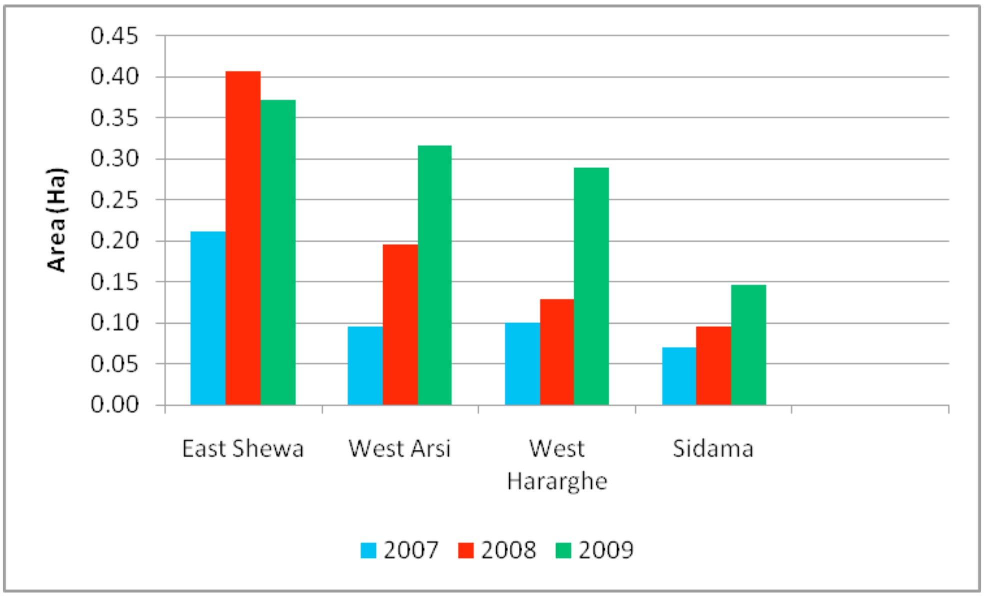


Figure 6-3: Average area (ha) per household occupied by improved common bean varieties in four zones of Ethiopia

Kenya

In Kenya, more than 60% of the farmers who planted any improved variety continued growing the variety after the first trial (Figure 6-4). Specifically, 74.5% continued growing KATB1, 66% of the farmers continued growing KatB9, 77% of the farmers continued growing Katx56 and 88% p of the farmers continued growing Katx69 (Figure 6-4). The expansion of the area under the improved varieties in Kenya seems to have been slower compared to Ethiopia, perhaps because of the severity of drought in Kenya, high diversity of varieties and subsistence nature of production that made some farmers eat all their harvest after first trial (Figure 6-4).

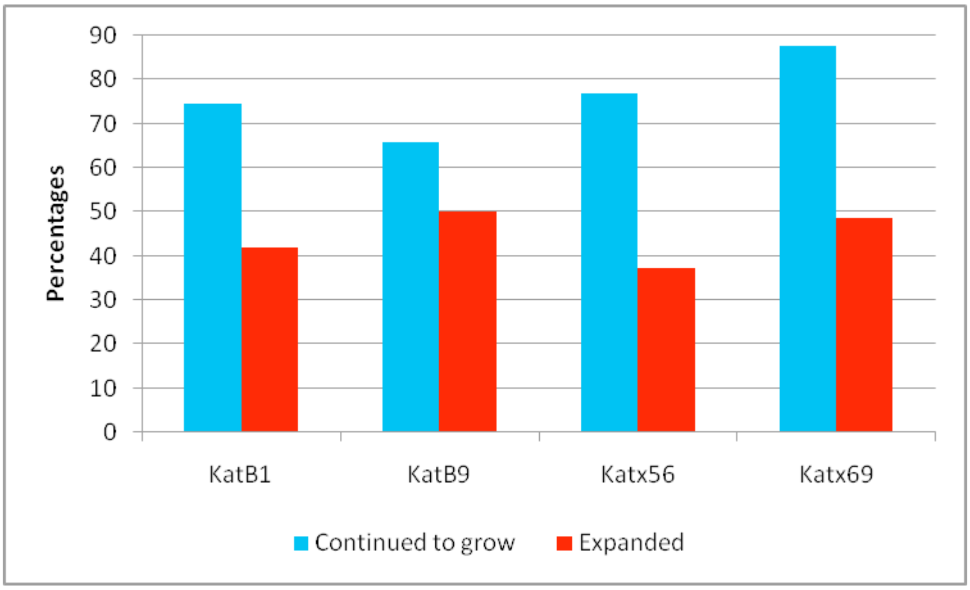


Figure 6-4: Percentages of farmers in eastern Kenya who continued to grow the variety after first trial and those who expanded area under the variety after trial

As in Ethiopia, varieties and information about improved varieties has diffused from the participating to non-participating farmers. About 60% of non-participating farmers were aware of at least one improved variety promoted under the project while 31% of the non-participating farmers were found growing at least one of the new varieties at the time of this study (Table 6-4)

Table 6-4: Diffusion of new varieties in Kenya

Variety	Participating farmers (N=104)	Non- participating farmers (N=162)	Combined	*t*-value
Variety awareness (%)				
Katb1	78.8	48.7	60.5	5.115***
Katb9	78.8	50.0	61.3	4.904***
Katx56	82.7	45.1	59.8	6.562***
Katx69	58.7	42.0	48.5	2.682***
At least one improved	98.1	69.1	80.5	6.192***
Variety use (%)				
Katb1	58.5	24.1	41.6	4.708***
Katb9	61.0	17.3	39.3	6.347***
Katx56	67.4	24.7	47.8	5.914***
Katx69	41.0	20.2	29.4	3.083***
At least one improved	92.3	30.9	54.9	12.267***

Source: survey data

Seed Production and Delivery Systems

Common bean seed production in Africa has faced a series of constraints which affect its volume, geographic scope and social reach of distribution. Public sector seed production has not been able to multiply large quantities of initial foundation seed—as priority for such foundation stocks is given to more commercial crops—such as hybrid maize. Further, when public sector does scale up, stocks are often diverted to emergency seed distribution, as common bean seed is a favorite 'relief crop' of both governments and NGOs. The private seed industry also has not found the common bean seed business lucrative, as once farmers get new germplasm they tend to re-sow from their own harvests for many seasons, instead of purchasing seed anew from certified sources.

The demand side has also faced a number of challenges--at the most fundamental level, many farmers simply do not know about new varieties (i.e. their potential advantages, where to access them, etc.). Seed production often takes place in higher potential areas, with seed stores also being concentrated in zones of higher population density or those with better infrastructure (that is, not the stress areas). Further, when seed of promising varieties is made locally accessible, it tends to be too costly (in relation to seed from local markets) and/or sold in package sizes of interest only to the larger-scale farmers.

For all these reasons, bean seed systems to serve the needs of the poor and to reach those in remote and less favored areas need to be specifically designed. The TL II common bean seed system component particularly focused on: 1)) decentralizing seed production in rural zones and 2) verifying dissemination and marketing strategies to reach all farmers, including women and those with limited financial means. In the process, we also set in place learning and innovation systems by a) analyzing costs and benefits; b) mapping geographic reach of agro-outlets; c) distilling principles for better practice in small pack marketing and d) working actively to stop bad practices - such as free emergency seed. The single lingering bottleneck on which there was only modest headway, remains the initial production of Foundation Seed. This critical initial foundation seed production step remains undiversified and is mainly in NARS (government) hands. The following briefly highlights in separate sections approaches tested, results, lessons learned, select monitoring and evaluation issues and training.

Approaches tested

In terms of production and delivery, approaches tested under Phase I included: four foundation seed production models, four models of decentralized seed production and seven seed delivery models (Table 6-5).

Table 6-5: TL II bean seed systems: approaches tested under TL II

Foundation/certified seed production	Decentralized seed production	Delivery approaches
• Direct production-NARS • Direct production-NARS seed unit with contract farmers • Private seed companies • Farmer cooperatives	• District/government officers supporting individual farmers • NGOs supporting individual farmers • Farmer Cooperatives/ Unions • Community-based seed production	• Small pack sales: open markets • Small pack sales: country stores • Small pack sales agro-dealers • Small pack sales: seed/grain traders • Exchanged through seed loans • Direct farmer to farmer diffusion • (GOK seed relief)

Results

Partnerships

Diverse and complementary partners have been the cornerstone of this work. Some 106 partners were involved in TL II bean seed systems in Phase I, including NARS, private sector companies, specialized seed producers, governmental and non-governmental organizations, community- and faith-based organizations and grain traders (Table 6-6). Partners developed joint work plans for project research and implementation, and agreed upon roles and responsibilities. Many of the partners also signed formal Memoranda of Understanding and several incorporated TL II work plans in their own organizational yearly program plans (examples in Kenya include Self Help Africa in Nakuru, several Catholic Dioceses, and NGO Nangina). Such transparent and formal commitments help to promote the sustainability of the intervention beyond the project cycle. The challenge now is to scale down partners so as to reduce transaction costs while maximizing reach. In Kenya, the main set of 'successful partners' has been the NGOs with strong local bases (e.g. Nangina and the Dioceses). In Ethiopia, farmer cooperatives have been identified as the most effective and sustainable seed production and delivery partners.

Table 6-6: TL II common bean seed systems: partners engaged, by country

Country	NARS	Specialized Seed Producers	GOs -NGOs	FO-CBOs- Faith-based groups	Grain traders
Kenya	KARI-Katumani KARI- Kisii KARI-Njoro	Leldet Dryland Lambwe Seed Growers	23	12	2
Ethiopia	EIAR SARI ARARI AREKA Haramaya University Hawassa University	Ethiopian Seed Enterprise Dawro + Shebedino MAP Private Cooperative ELFORA Agro-Industry Ltd Haile Waqo Private Seed Farm	46	19	4

Seed production

Seed production of various types of seed was monitored throughout the project cycle. NARS kept careful records of initial foundation/certified seed produced and distributed to partners, while select partners in decentralized zones kept records of farmer multipliers, farmers receiving seed, and multiplication rates by region. Monitoring with individual farmers also provided data on how the individual harvest was used (e.g. whether eaten, stored, saved as seed, exchanged, and sold as seed or grain). Table 6-7 shows the overall seed multiplied and compares it with the original milestones set. Annex 6-2 (parts (a) and (b)) shows in more detail how the calculations for decentralized seed multiplication were made, along with the guiding assumptions, using the example of Ethiopia. (Note that the assumptions, that is, process variables based on actual field data, are different for Kenya).

Table 6-7: TL II common bean seed systems: seed production (MT) in Phase 1

Country	Foundation/Certified seed production		Decentralized seed production	
	Target	Actual*	Target	Actual**
Kenya	35.00	34.02	740.00	1,249.90
Ethiopia	93.00	174.50	1,130.00	7,779.90
Total	128.00	208.50	1,870.00	9,029.80

**More partners added; **Includes seed in small packs*

Going more in-depth on the seed production process, in Kenya, monitoring of seed multipliers between 2008 and 2009 showed that between 61.1% and 80.3% of the seed producers were women (no comparable figures are available for Ethiopia) and that even small-scale seed producers are able to reserve between 42% and 46% of their harvest for use (and sale as seed specifically). Varietal diversity was also being encouraged in seed production efforts: in Kenya four varieties were diffused for drought-prone zones; in Ethiopia, the figure was 10 varieties (including food and export-canning types).

Seed delivery mechanisms: small packs and seed loans

Small packs

The use of small packs is based on the field insights that farmers want access to new varieties, and that some also are willing to pay for certified seed *per se*. Seed simply has to be marketed in affordable sizes, in places which are easily accessible to farmers, and from vendors that farmers trust (or who may be held accountable to buyers). Available M+E data show that 81,654 packs were sold across the two countries (with this count representing the minimum packs sold, as a number of partners did not report back specific sales figures).

In Kenya, the small seed pack approach was pioneered by KARI and the Leldet Seed Company, especially across the Central Rift Valley and Central and Eastern Kenya. Packs have been sealed in 70-100 g, 400 g and 2 kgg sizes and sold at Ksh 10, Ksh 50 and Ksh 180, respectively (1USD = Ksh 80). One M+E follow-up showed that 58% of buyers were female, with the majority preferring the 70 g pack, which they can afford with their domestic funds. The marketing took place during agricultural-shows, field days, agro-dealers and open market places. Follow-up shows that women are as likely to purchase as men. Further, sale of small packs is expanding business opportunities for seed companies--- as even small farmers are now purchasing certified seed. Dryland Seed Co. and Kenya Seed Co. (the largest seed company in Kenya) indicate that they will now use the small pack approach, especially for marketing climbing beans.

In Ethiopia, packs were sold in the eastern and southern parts of the country through farmers' cooperative unions, NGOs and in open market places. Given the very modest buying power of Ethiopian farmers - and the secondary role of common bean - the lively interest in small bean packs was unexpected. Also, the small pack approach changed Project understanding of farmers' wants and needs. At the beginning of TL II, NARS and NGOs considered that farmers only wanted large quantities, that is 50 kg and 20 kg packs. EIAR and SARI then moved to putting on offer 5 kg and 2 kg packs. Now, sales data are showing that many Ethiopian farmers desire smaller amounts - even 200 g, 500 g and 1 kg packs, particularly as they expand to new varieties. EIAR has even made excellent progress selling packs in the highly drought-stressed zones of Hararghe, where farmers may have <0.5 ha of land. Both EIAR and SARI have also used the small pack approach to encourage diversity. Seven different varieties were marketed in 2010 alone.

In terms of marketing queries, the following are seen as important next steps:

- Conduct a cost benefit analysis for small packs to help partners reflect on the challenges;
- Conduct a market survey to determine farmers' demand for different size common bean seed packs, and varieties by region and type of farmers;
- Explore possibilities for cross-crop cost-sharing of promotion and sale of seed. Cross crop input promotions should reduce the cost of marketing small packs.

Seed loans

The magnitude and effectiveness of seed loans has also been a surprise. For instance, in western Kenya alone, partner estimates show 90,000 farmers have accessed seed directly through loans in just three seasons (and with no money changing hands). Precise follow-up, through a specially commissioned MSc suggests that the indirect reach may be even more notable. To date, on average five farmers have received seed from the initial contact farmers, with one farmer having given to 14 others just in the period from March to September 2008. M+E suggests that the seed loan approach spreads seed fast.
The success of this seed loan approach, has also spurred interest in Kenya—to use it as an alternative to free seed distribution, even during emergency. This change is currently being planned for Eastern Kenya

Traders

Both small packs and loans complement efforts of local traders - who sell seed (the right variety and good quality) as well as grain. Under TL II, we have linked with traders, but have not yet learned how to monitor their activities sufficiently. Direct collaboration with traders under TL II has played a role in southern Ethiopia, where traders have contracted trained farmers to multiply seeds that are subsequently sold to NGOs and other local traders. To give an idea of scale, in 2009, a single trader (buying from farmers) sold 10 MT of project-related varieties to four NGOs, and 5 MT to other traders.

Mapping (GIS) seed outlets

Related to marketing - and to reach 100,000s farmers in general, a complementary project (Nodes of Growth, leveraged on TL II) mapped the distribution of seed outlets in key drought-prone zones of Kenya. Such maps help to identify areas where there is a lack of coverage.

Starting with Nzaui district in Kenya, the map showed that just over 23% of the population is reached within 1- hour walk of the current seven outlets. If one new outlet were added, the population within 1-hour reach rises to 38%. A further seven new outlets would have to be added to ensure that 80% of our target population has access to seed outlets. So, in brief, the current placement of agro-dealers suggests that they can serve only a small portion of the population in this particular drought-prone zone. To reach a broader segment, either more outlets have to be added, or alternative mechanisms of supply have to be encouraged (such as at open markets).

Select monitoring and evaluation issues

An Integrated Performance Monitoring and Evaluation (IPME) framework has been built into project operations at varied levels—with the decentralized partners, the NARS, and overall with PABRA/CIAT. Routine data on seed produced, distributed, and sold is collected, along with insights on who is being reached and where. In addition, specialized M+E is being conducted on the costs of seed production, and on the quality of seed being produced by different organizations.

Cost-benefit analysis of decentralized production models

Seven models were costed and their advantages and disadvantages analyzed during Phase I. The focus has been on Kenya—and included one public sector organization, two private companies, and four decentralized means of production (facilitated by individuals, communities, and NGO and the government sector, respectively). Producing common bean seed proves profitable whether the product is certified or of 'other quality', but the magnitude of profit is highly linked to yield. Currently, all modes are vulnerable to the adverse effects of drought.

Seed quality monitoring

Seed quality assessment research was conducted in both countries comparing samples obtained from varied formal and informal seed sector sources.

In Kenya, seed was collected from trained seed bulking farmers, farmers who were secondary beneficiaries, and seed companies and parastatals involved with seed. The data from 91 farmer beneficiaries (74% women), randomly sampled across TL II sites, proved of particular interest. Data analysis showed that 81% of farmers' sorted seeds were of good physical quality (according to ISTA standards), with a germination of 86.7%, and with very good vigor.

In Ethiopia, 169 bean seed samples were collected from the Oromia and SNNPRS regions, including seed samples obtained from the formal seed sector (seed companies, famers' cooperatives unions and research centers) and local markets in the areas of project intervention. Physical purity proved relatively good across samples, ranging from 89.2% to 100 % with a mean of 97.5%. Germination percentage showed a greater range, between 68 and 97.3 with a mean of 78.9%. Seed health testing was also conducted for the two most important common bean bacterial pathogens; *Xanthomonas campestris* pv. *phaseoli* and *Pseudomonas syringae* pv. *phaseolicola*. In terms of the informal sector, some common bean growers had produced seed of considerably better quality than others. There were cases where seeds obtained from the formal sector fell below the minimum standards. Hence, the results showed that there was no evidence to assume that seeds from the decentralized seed system are inferior to that of the seed from the formal sector.

Summary, process gains and people reached

Product gains

TL II bean seed systems have made important advances in Phase I of the project. In terms of actual products, a notable amount of foundation seed has been produced, with NARS mainly overseeing the process. Also, a remarkable amount of decentralized seed production has taken place, with the latter accomplished by facilitating numerous and diversified partnerships. Important to highlight is that the varieties being promoted are doing unusually well on-farm (see Objective 4 & Objective 1 results). The good performance of Katumani – common bean varieties, in general, has encouraged more investment in the bean sub sector. For instance, a new producer of certified seed, Lambwe Seed Growers Association, has been recently licensed by KEPHIS (the Kenya seed health sector). In addition, the Kenya Ministry of Agriculture (fortunately or unfortunately) has started supplying Katumani common bean varieties as relief seed in 61 districts across Kenya.

Process gains

Equally important are processes or innovation gains, which will extend well beyond the life of a special project, such as TL II. Phase I has shown that:

- Women can be engaged in and benefit from seed production;
- Cost-effective models for seed production are being implemented (caution: although vulnerable to drought)
- Farmers, including women, will pay for certified seed; there is real demand!
- Small pack marketing can be taken up by the private sector; (and is being taken up- especially in Kenya). The approach is also expanding across crops.
- Seed loans are an effective mechanism for moving seed widely, including among those with limited financial means.
- Seed loans offer an alternative to emergency free seed distribution practice (and will be substituted in Eastern Kenya).

Each of these innovation gains can and should be built on more widely.

People reached

Finally, in terms of documented impact, TL II common bean seed system has made an initial calculation of people reached. These calculations have been derived from field data on initial seed produced, and then extrapolated using insights from known field processes. Our calculations may be on the modest side, for three reasons. 1) We used the seed sharing rate of a) one farmer to one additional farmer after the first season of use and b) two additional farmers after two seasons. However, an MSc study on actual seed loan suggests that the average may be to five other farmers. 2) We have assumed that only 80% of farmers in Kenya and 70% in Ethiopia distribute at all. 3) The data on reach has not been able to capture new variety and seed use that derives from local market purchase. (This may be a big gap). So we consider these calculations to be transparent, but provisional. The figures are likely to be higher. Table 6-8 shows the overall figures on reach: 1,099,736 people. Annex 6-3 shows the actual calculations and the underlying assumptions, again using Ethiopia as the example. It is important to note that only seed and reach directly achieved under the TL II project is reported. KARI and EIAR also have other projects, partners and impacts.

Table 6-8: Farmers reached in Phase I

Country	Farmers reached
Kenya	634,905
Ethiopia	464,831
Total	**1,099,736**

Lessons learned

TL II bean seed systems Phase 1 lessons are listed below.

1. Impact- oriented core team of a program is key for developing seed systems in drought-prone regions, geared to reach the poor. A program cannot get impact unless the leader and the team gear strategies to solving bottlenecks and reaching end users. Otherwise, a program ends up with results like 'lots of seed produced'- on the supply side.

2. The professional and transparent engagement of partners is crucial for widespread success. This includes formal clarification of expectations /responsibilities and clear budget allocations. Productive partnerships require ongoing facilitation. More is not better - effective partners, private sector, NGO , unions and beyond, need to be identified who will continue production and delivery beyond the project (after TL II exit). A better characterization of successful partner attributes could be useful.

3. Availability and access to foundation/certified seeds remains a bottleneck. Despite having created high farmer demand and interest in the drought-tolerant varieties, foundation seed production remains solely in the hands of the NARS and access to new varieties and initial seed by seed companies or other seed producers remains limited. In addition, the capacities of seed companies to produce certified seed is still very low (or non-existent), hampered by limited technical know- how, as well as recurrent drought. For instance since project initiation, only one of the two companies licensed to produce certified seeds has been able to supply any seed at all. On a positive note, in Ethiopia, EIAR/ Melkassa is actively looking to private seed farms as one potential new source for certified seed.

4. Decentralized systems have proven to be durable, functioning even during times of severe production fluctuation (due to political unrest and drought). Strengthening decentralized centers of production will become even more important as climate change intensifies.

5. A small pack marketing approach has potential to reach hundreds of thousands of farmers, quickly, including women . In both Ethiopia and Kenya, the sale of small packs has reached male and female farmers in but a few seasons, and expanded the use of certified seeds. It has also given farmers the opportunity to experiment new varieties - at minimum risk. The small-pack model has already spread to other crops and to six other PABRA countries.

6. Seed loans can be an effective mechanism for moving seed intensely within a community, and without involving any monetary exchange. Follow-up, showing that a single farmer may distribute to 14 others, in just three seasons, suggests the potential reach of this approach. The main requirement is to have a strong, grassroots-based implementing partner.

7. Emergency seed distribution can clash with project goals. Emergency supply orders directly compete with project needs for foundation/certified seed. Further, free distributions clash with the project optic of selling seed and creating demand among small farmers. Emergency and Development efforts in seed system development need to be better coordinated and need to be designed to complement each other. Some gains have been made in Kenya --- where the Government of Kenya will be substituting seed loans for direct free distribution, at least in the eastern drought-prone areas.

8. Monitoring and evaluation have been crucial for understanding project opportunity and constraints. Considerable energy was expended to develop and put in place the Integrated Performance Monitoring and Evaluation (IPME) processes of the project and such start-up efforts should not be underestimated. Moreover, IPME has also delivered quickly—especially in identifying some of the quick wins of the project.

Fast-Tracking and Technology Generation

Elite materials shared with the NARS programs

At the outset of the TL II project, a nursery was compiled of more than 1700 entries, with contributions from PABRA (eastern Africa – ECABREN; and southern Africa - SABRN), as well as from CIAT headquarters in Colombia. Some materials had been selected under drought stress previously, especially those from CIAT-Colombia, while others were derived from regional nurseries, for example, the BILFA (Bean Improvement for Low Soil Fertility in Africa) nursery composed of selections made under various low fertility regimes. Others were elite lines from general breeding nurseries.

Given limitations of seed in early stages, a first nursery was planted in KARI, Katumani, Kenya in two repetitions and short rows. The nursery developed well vegetatively and suffered a moderate level of terminal drought stress with some late rains. It was, however, a useful nursery as a first evaluation of drought response of lines, many of which had not been exposed to moisture stress previously. From this nursery a sub-set of 500 entries were identified for subsequent distribution to other research sites in the ECABREN region.

The nursery in Katumani served a training purpose as well. Since it was the first nursery planted under the TL II project, which was the most significant effort in drought resistance to date, the nursery was also the first significant opportunity to expose regional scientists to physiological sampling techniques for the evaluation of drought resistance traits. Moreover, it was the first opportunity to test the physiological parameters that had been identified in CIAT-Colombia as potential indicators of drought resistance. A description of the training exercise per se is presented in the section on capacity building. With regards to the results of the physiological analysis, both pod harvest index (seed biomass/pod biomass x 100) and pod partitioning index (pod biomass at harvest/total shoot biomass at mid-pod fill x 100) proved to be closely associated with seed yield (Figure 5; Table 9), validating results from Colombia.

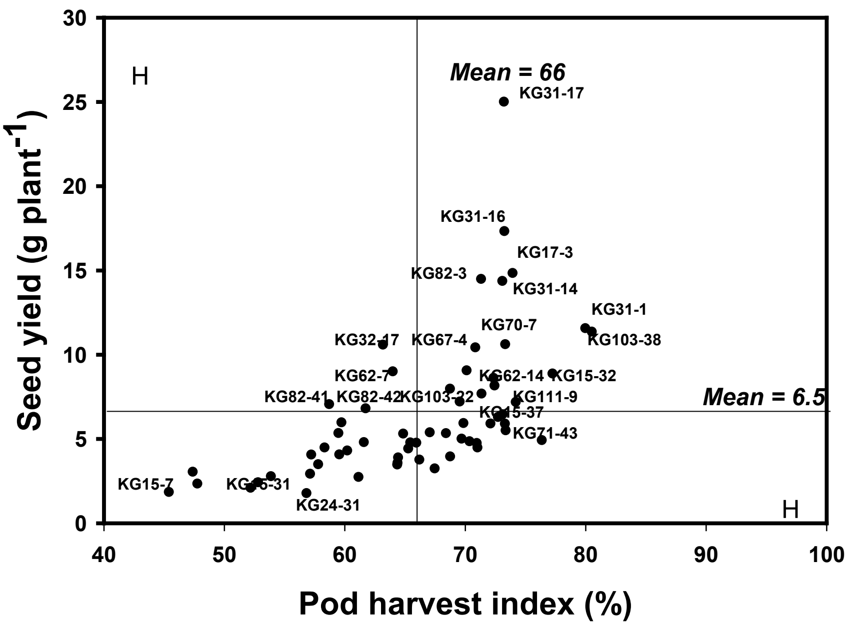


Figure 6-5: The relationship between pod harvest index and seed yield in lines planted under drought stress in Katumani Station, Kenya.

Table 6-9: Correlation coefficients between seed yield and physiological parameters measured on entries in a drought screening in Katumani, Kenya. January, 2008.

Plant attributes	Correlation coefficient
Shoot biomass (g plant^{-1})	0.31
Pod partitioning index (%)	0.87
Pod harvest index (%)	0.58

The same nursery of 1700 entries was planted in Kandiyani Research Station of DARS, Malawi, under the SABRN network but suffered severe attack by bean stem maggot (BSM; *Ophiomyia* sp.). Attack of BSM was a natural result of late planting that was practiced to simulate terminal drought stress, and this delayed progress in SABRN. Fortunately, materials that had been selected under a parallel project on drought were advanced, and these were employed in PVS trials while the TL II nursery caught up.

PVS trials and lines in the pipeline

KARI-Kenya

The fast track activities were initiated in KARI, Katumani, and were carried from there to dryland sites throughout eastern, central and western Kenya. During the first season of 2009, five PVS were conducted: three in Central province and two in Rift Valley province. Women and men farmers were invited to evaluate the test genotypes at physiological maturity stages using the ribbon method. During the exercise, 18 lines were selected. In the second season of 2009, the 18 test genotypes and six checks (KAT B1, KAT B9, KAT X56, KAT X 69, GLP x 92, and GLP 1004) were evaluated in both on-farm and on-station trials. Eight on-farm trials were established (Table 6-10, Figure 6-6), evaluated with farmers, and yield was estimated. On-station trials were grown under irrigation and under managed stress at KARI's Kiboko station in eastern Kenya.

Check varieties GLP x 92 and KAT B1 were identified in the baseline study as the two better yielding varieties in farmers' hands at the outset of the project. However, in two seasons on farm, and under managed stress at Kiboko, these were inferior to the newer KARI varieties being distributed in Objective 8. Furthermore, lines being tested yield far better than the KARI varieties, with an advantage of as much as 80% over the best check. Table 6-11 presents yield results of the most promising and stable lines. Five lines will be submitted for national performance trials (NPTs) in the second season of 2011.

Table 6-10: Latitude, longitude and altitude for PVS trial sites, Kenya

Province	District	Trial Site	Latitude	Longitude	Altitude (masl[1])
Rift Valley	Naivasha	Kiptangwanyi	S 0.57	E 36.11	2054
	Nakuru	Wanyororo	S 0.30	E 36.17	1929
Central	Murang'a South	Makuyu	S 0.86	E 37.18	1338
	Kirinyaga	Mwea	S 0.71	E 37.26	1160
	Kirinyaga	Kirinyaga	S 0.64	E 37.24	1227
Eastern	Mbeere North	Kangeta	S 0.68	E 37.51	1119
	Mbeere South	Kiambere	S 0.74	E 37.78	948
	Mwala	Mwala	S 1.36	E 37.45	1246

[1]masl = meters above sea level

Figure 6-6: Distribution of PVS sites in eastern, central and western Kenya.

Table 6-11: Yields (kg per ha) of elite selections from on-farm and on-station evaluation of lines from the fast track nursery.

Type/category		Average, 8 on-farm sites		Kiboko, Managed stress	
	Line #	LR 2009	SR 2009	Non-stress	Stress
Red mottles	2	1628	1318	2314	1125
	3	1847	1163		
	4	2018	1546	2065	1103
	5			2254	1178
Red kidney	7	2102	1326	2018	968
	8	1737	1027	2138	1016
	KAT x 56			1958	453
	KAT x 69	1363	718	1874	648
	KAT B9	589	514	797	378
	KAT B1	659	486	662	357
	GLP x 92	624	364	968	291

SARI-Northern Tanzania

The team in Selian Research Station in Arusha received lines of the fast track nursery from the University of Nairobi, and followed up over several cycles of testing. Lines were divided into two groups: bush types and indeterminate vining types, and were yield-tested on-farm in three regions (Tables 6-12 and 6-13). Lines were also subjected to PVS evaluation with farmers using colored ribbons to express favorable or unfavorable opinions of the materials (Figure 6-7). Farmers' criteria are presented in Tables 14 and 15. Lines which expressed better yields and were also rated well by farmers include F9 Kidney selection (15), F8 Drought line (36), and Dwarf climber (6).

Figure 6-7: Farmer evaluation of fast-track lines at SARI-Tanzania.

Table 6-12: Yields of fast track bush types in three regions of northern Tanzania.

Germplasm/variety	Seed size	Seed color	Masaera Yield (Kg per ha)			Mijongweni Yield (Kg per ha)			Koboko Yield (Kg per ha)			Grand mean
			Site 1	Site 2	Mean	Site 1	Site 2	Mean	Site 1	Site 2	Mean	
1. F_9 Kidney Selection (15)	Large	Red Kidney	940.6	1711.4	1326.0	619.1	476.2	547.7	1011.7	718.3	865.0	913
2. KG 111 (29)	Large	Cream	946.2	691.4	818.8	571.4	428.6	500.0	1032.7	661.5	847.1	722
3. Navy Lines (25)	Small	White Navy	1315.4	1370.3	1342.9	857.1	285.7	571.4	806.2	1336.1	1071.2	995
4. F_8 Drought Lines (14)	Small	Red Kidney	1017.9	403.8	710.9	761.9	152.4	457.2	1018.9	427.2	723.1	630
5. Biofort Large (4)	Large	Calima	1140.4	892.1	1016.3	523.8	666.7	595.3	323.9	1137.4	730.7	781
6. F_8 Drought Lines (7)	Medium	Calima	1159.4	650.5	904.9	571.4	380.9	476.2	942.4	873.7	908.1	763
7. Dwarf Climber (18)	Medium	Purple	776.2	628.9	702.6	476.2	333.3	404.8	457.1	1273.7	865.4	658
8. F_{10} Red Mottled	Medium	Calima	631.2	435.9	533.6	761.9	238.1	500.0	376.9	1490.1	933.5	656
9. F_8 Drought Lines (36)	Large	Cranberry	1821.6	1239.6	1530.6	333.3	571.4	452.4	713.9	899.1	806.5	930
10. Jesca	Large	Purple	1503.2	510.4	1006.8	476.2	142.9	309.6	960.1	1457.8	1208.9	842
11. Lyamungu 90	Large	Calima	900.9	739.1	820.0	190.5	476.2	333.4	829.6	1075.7	952.7	702
12. Soya Manjano	Large	Purple	640.0	856.1	748.1	190.5	190.5	190.5	422.4	334.5	378.5	439

Table 6-13: Yields of fast track indeterminate vining types in three regions of northern Tanzania.

Germplasm/variety	Seed size	Seed color	Masaera Yield (Kg per ha)			Mijongweni Yield (Kg per ha)			Koboko Yield (Kg per ha)			Grand mean
			Site 1	Site 2	Mean	Site 1	Site 2	Mean	Site 1	Site 2	Mean	
1. KG 98 (23)	Small	Pinto	749.2	1090.7	919.9		95.2	333.3	1382.7	989.8	1186.3	813
2. KG 98 (18)	Small	Pinto	1639.4	357.1	998.3	813	47.6	261.9	893.5	285.7	589.6	617
3. Navy Lines (8)	Small	White Navy	1686.9	398.3	1042.6	617	38.1	328.6	759.5	1381.7	1070.6	814
4. KG 98 (36)	Small	Pinto	1164.0	424.93	794.5	814	-	285.7	931.0	291.9	611.5	564
5. Dwarf Climber (6)	Medium	White Navy	963.5	1589.2	1276.4	564	428.6	404.8	1091.8	1185.2	1138.5	940
6. SARBYT 1 (3)	Medium	Calima	621.5	704.8	663.2	940	190.5	166.7	854.5	774.1	814.3	548
7. KG 98 (42)	Small	Pinto	915.1	606.8	760.9	548	38.1	66.7	299.7	1094.1	696.9	508
8. Selian 94	Medium	Pink	1190.9	589.0	885.5	508	47.6	119.1	830.3	462.1	646.2	550
9. KAT B 9	Medium	Red	1521.2	398.6	959.9	550	95.2	66.7	508.7	915.6	712.2	580
10. Soya	Medium	Purple	698.2	881.7	789.9	580	190.5	119.1	312.5	694.9	503.7	471
11. Selian O5	Small	Khaki	1195.6	751.5	973.6	471	38.1	114.3	942.3	1064.9	1003.6	697
12. Soya Manjano	Large	Yellow	1065.7	1267.1	1166.4	697	95.2	142.9	311.8	858.5	585.2	632

Table 6-14: Farmer evaluation of bush bean lines in northern Tanzania

Entry	Variety	#Positive Ribbons		#Negative Ribbons		Farmers' Comments	
		Men	Women	Men	Women	Men	Women
1	F9KIDNEY SELECTION (15)	3	3	3	1	Potential good marketability	Potential good marketability
2	KG 111(29)	0	0	0	0		
3	NAVY LINE (25)	1	1	0	0	Potential good marketability	Palatable
4	F8 DROUGHT LINE (14)	4	1	0	0	High yield; no gas; early maturing; palatable	Potential good marketability; high yield; no gas; early maturing; palatable
5	BIOFORT LARGE (4)	0	0	0	0	Poor yield; poor potential marketablity	Poor yield
6	F8 DROUGHT LINE (7)	2	0	0	0	High yield	Gas Poor potential marketablity
7	DWARF CLIMBER (18)	0	0	1	0		Poor grain color
8	F10 RED MOTTLED	0	0	0	1	Early maturing	
9	F8 DROUGHT LINE (36)	2	2	1	1	Good seed size; potential good marketability	Palatable
10	JESCA	2	2	1	3	high yield; no gas, Potential good marketability	Not familiar
11	LYAMUNGU 90	1	0	3	6	flatulence	Good for local dishes; high yield
12	SOYA MANJANO	3	4	0	0	High yield; no gas;potential good marketability	

Table 6-15: Farmer evaluation of indeterminate bean lines in northern Tanzania

Entry	Variety	#Positive Ribbons		#Negative Ribbons		Farmers Comments	
		Men	Women	Men	Women	Men	Women
1	Kg 98 (23)	1	0	3	1	High yield	High yield; potential good marketability
2	Kg 98 (18)	2	1	3	1	High yield	High yield; potential good marketability
3	Navy Lines (8)	2	1	3	2	Poor yield	Poor yield; not good climber
4	Kg 98 (36)	0	2	0	0	Good seed color; palatable	Potential good marketability; palatable
5	Dwarf Climber (6)	2	3	2	1	Good seed color; palatable	Potential good marketability; palatable
6	Sarbyt 1 (3)	0	0	4	1		Potential good marketability; palatable
7	Kg 98 (42)	3	5	0	2	Good seed color; palatable	Potential good marketability; palatable
8	Selian 94	1	1	0	3	Good seed color ; palatable	Potential good marketability; palatable
9	KAT B9	1	3	1	0	Good for local dishes	Poor potential marketablity
10	Soya	1	3	2	1		
11	Selian 05	0	0	2	3	Poor yield; shattering easily	Poor yield
12	Soya Manjano	3	1	2	1	H	high yield; palatable

Ethiopia

Results of selection within the fast track nursery were less successful in the program in Melkassa in the sense that no line convincingly out-yielded a local check, Nasir. This variety proved to be quite drought tolerant, likely due to its history of selection. First, it was originally selected in Honduras in a region that is subject to drought, and thus could have experienced drought pressure during its development. Secondly, a Mexican race Durango accession is among its parental lines, and race Durango has been a source of drought tolerance.

On the other hand, recombinant inbred lines introduced as part of a PhD thesis proved to be quite successful for the identification of high yielding navy beans for Ethiopia's export market, both in managed drought trials in which they out-yielded the check amply (data not shown), and in regional trials (Table 6-16), although in 2010 rainfall was plentiful and yield data do not reflect drought in this particular year. Selections 23 and 80 were especially stable, yielding 11% and 12% more than the elite check Awash-Melka across environments, and 29% and 19% better in the lowest yielding environment (Pawe). (Awash-Melka was distributed as an elite variety under Objective 8.) Disease data were taken at all four test sites, although only data from Jimma are shown, given that disease pressure was especially intense there. Several lines were superior to Awash-Melka in resistance, especially line 23 which was superior for reaction to four diseases. In evaluations with traders all lines were quite acceptable, while line 80 was rated very high in canning quality in tests carried out in Italy.

Table 6-16: Seed yield (kg per ha) of sixteen small white navy beans (material with Awash 1 genetic background) grown at four location in Ethiopia during the main season of 2010

Entry	Variety	Location					Diseases (Jimma)			
		Pawe	Alem Tena	Mel-kassa	Jimma	Mean	ALS	CBB	Rust	FLS
1	ICN Bunsi x SXB 405/1C-1C-1C -1	810	2641	3165	1933	**2137**	5	8	2	7
2	ICN Bunsi x SXB 405/1C-1C-1C -3	731	3854	2972	2270	**2457**	5	8	5	7
3	ICN Bunsi x SXB 405/8C-1C-1C-13	640	2801	2125	2345	**1978**	5	7	8	7
4	ICN Bunsi x SXB 405/9C-1C-1C-14	926	3198	3277	1364	**2191**	4	6	2	7
5	ICT Bunsi x SXB 405/2C-1C-1C-23	1070	2376	3294	2462	**2301**	3	4	1	3
6	ICT Bunsi x SXB 405/7C-1C-1C-30	769	2833	3165	1641	**2102**	5	7	1	6
7	ICT Bunsi x SXB 405/2C-1C-1C-37	1077	2381	3077	2266	**2200**	4	7	5	6
8	ICT Bunsi x SXB 405/5C-1C-1C-51	803	2300	3179	1531	**1953**	5	8	3	8
9	ICT Bunsi x SXB 405/7C-1C-1C-58	676	2781	3260	2087	**2201**	4	6	2	6
10	ICT Bunsi x SXB 405/2C-1C-1C-23	929	2239	2683	2102	**1988**	3	5	6	7
11	ICT Bunsi x SXB 405/9C-1C-1C-70	1064	2353	3479	1487	**2096**	4	6	1	6
12	ICT Bunsi x SXB 405/4C-1C-1C-80	992	2295	3278	2753	**2329**	3	5	3	7
13	ICT Bunsi x SXB 405/3C-1C-1C-87	772	2360	2759	2039	**1982**	3	6	4	5
14	ICT Bunsi x SXB 405/4C-1C-1C-88	810	2336	2510	1950	**1901**	5	7	8	7
15	Awash - 1 (check I)	811	1435	2243	2020	**1627**	4	6	9	8
16	Awash-Melka (check II)	828	2598	3217	1628	**2068**	5	7	3	8
	Mean	**857**	**2549**	**2980**	**1992**	**2094**	**4**	**7**	**4**	**7**

Disease score on a 1-9 scale

Malawi

Evaluation of the fast track nursery in southern Africa was delayed due to attack of bean stem maggot or bean fly (*Ophiomyia* spp.), which was exacerbated by late planting of nurseries to increase probability of drought stress. Lines are still being processed, but in the off-season nursery in Kasinthula 51 lines produced 30% more grain that the average of four checks, although almost none beat the best check by this margin. We have noted that lines selected in the Malawian program have performed well in other environments, and local materials might have a degree of tolerance already.

While the fast track entries were recovered and cycled through the evaluation scheme, lines selected previously under a parallel project were advanced and are at the point of release. Across four sites including two on-farm sites in the north of Malawi (CHS and BOK), small red seeded lines out-yielded the local check CAL 143 by as much as 50% (Table 6-17). Although not the most preferred type in Malawi, small red beans do appear in local mixtures. The national program is considering the release of SER 83 and SER 45.

Table 6-17: Performance of drought resistant bean genotypes on yield and reaction to major diseases obtained from on-station and on-farm sites

Identity	Reaction to major diseases (scale: 1-9)					Grain yield (kg per ha)				
	*Anth	Asco	Rust	CBB	BCMV	NRC	CZ	CHS	BOK	Mean
SER 83	1	7	1	1	1	2649	3299	2498	1497	2486
SER 45	2	7	1	1	1	2476	2685	2507	1878	2387
MR 13456	1	7	1	1	2	1312	3275	2469	1513	2142
SER 53	4	6	1	1	1	1791	2326	2855	1463	2109
SER 85	1	7	1	1	1	1120	3194	2093	1636	2011
SER 43	1	7	1	1	2	1358	2500	2211	1863	1983
SXB 405	2	7	1	1	1	1220	3194	1872	1608	1974
SER 79	1	5	1	1	1	1657	3351	1028	1634	1918
BF 13572-5	1	7	1	1	2	1388	2622	1992	1499	1875
BF 13607-9	1	4	1	1	3	1671	2361	1623	1812	1867
TIOCANELA 75	5	7	1	1	2	1658	2865	1598	1233	1839
SER 81	1	5	1	1	1	1620	2691	1655	1255	1805
MR 14215-9	4	7	1	1	1	2014	1979	1873	1317	1796
SER 55	1	5	1	1	1	1378	1958	2190	1400	1732
SER 124	1	4	1	1	1	1414	2049	1979	1429	1718
SER 80	1	7	1	1	2	1423	2378	1454	1564	1705
SER 75	1	4	1	1	1	1702	2431	1618	979	1683
SXB 413	1	4	1	1	3	1591	2448	1450	1097	1647
CAL 143 (Check)	1	6	1	1	2	2454	2535	705	853	1637
SER 78	1	6	1	1	2	1193	2778	741	1690	1601
BF 13607-12	1	5	1	1	3	1818	1510	1422	1368	1530
SER 72	1	7	2	1	1	1651	1858	1010	1507	1507
VTTT925/9-1-2	1	4	1	1	1	2330	2135	1447	1149	1436
VTTT924/19-8-1	1	7	1	1	1	1792	1580	1081	1278	1316
PC652-553/VAX5	3	5	2	1	2	1014	1771	838	813	1109
Mean	2	6	1	1	2	1680	2442	1588	1395	1776
$LSD_{0.05}$	1.3	0.9	0.3	1.0	2.0	425.7	469.3	552.5	163.6	
CV%	47	9	18	50	90	36	42	32	40	

Zimbabwe

A total of 1007 lines were first evaluated for adaptation and photosensitive response under irrigation at Harare Research Station in August 2008. Not all lines were adapted, and those that excelled were planted again in two sets, one under water stress and the other under irrigation in February 2009 at Gwebi Variety Testing Centre. However, the crop in the irrigated field was partly grazed by antelopes during the trifoliate stage. Drought in the water stress treatment was not severe as expected since some unexpected rains were received during the early podding stage, but 200 lines were selected under these drought conditions.

In 2009/10 summer season, the selected 200 lines were sent to farmers for participatory variety selection, to expose genotypes to natural drought conditions and farmer environment, improve efficiency of researcher's selections, meet standards of variety release and increase chances of variety adoption once released. Most parts of the country received below average rains and persistent dry spells were recorded, giving rise to two types of drought, depending on region/district. One scenario was drought which affected beans at flowering stage (mid season drought) and the other case where late planting was done that favored terminal drought. There was also an extreme scenario where the rains did not even support seed germination in known drought-prone areas like Gutu and Mushagashe in Masvingo province.

Of the 200 lines, farmers from different areas managed to select 30 lines. Farmers' selection criteria were mainly based on varieties resistant to drought since 2009/10 year was a drought year. We managed to receive a few grams/line from farmers since the majority of farmers retained some of the seed. The varieties which were selected by farmers under farmer fields have been reconstituted into one nursery and are currently being bulked up at Harare Research Station to enable on-station trials under drought conditions in the Lowveld during winter 2011. Physiological parameters for drought tolerance will be precisely measured. Multilocation variety evaluation will then follow, with possible release of at least one drought tolerant variety in 2012/13 season.

Number of segregating materials generated

Segregating populations were developed for selection in CIAT-Colombia, in CIAT research sites in Africa, and in NARS programs. Based on evaluations made in Colombia, elite parental lines were selected for another cycle of crossing with emphasis on beans of the Andean gene pool. Approximately 60 populations were evaluated per year in CIAT-Colombia. Other populations were sent to partners in four of the five participating countries, while in Zimbabwe, the program focused on giving follow up to existing populations (Table 6-18). Additional crosses were made in the Ethiopian program (Table 6-19), and parental materials were delivered to KARI-Kenya to initiate a crossing program there.

Table 6-18: Numbers of segregating populations delivered to national program breeders for local selection.

Country	Number of F2 Populations	Other Populations
Ethiopia	52	-
Kenya	15	48 F4
Malawi	21	59 F4
Tanzania	5	-
Zimbabwe	-	F5 from previous project

Table 6-19: Simple crosses made at Melkassa Research Center, EIAR, Ethiopia, for subsequent use in multiple crosses

No.	Cross	No.	Cross	No.	Cross
1	Capsula x Awash-Melka	11	NASIR x SER-128	21	Chore x SAB-713
2	Capsula x SAB-712	12	NASIR x SER-78	22	Chore x MEX-142
3	Capsula x SAB-713	13	Awash-Melka x MEX-142	23	Dimtu x SER-176
4	Capsula x VAX-3	14	Awash-Melka x VAX-3	24	Dimtu x SER-128
5	Capsula x COS-16	15	Awash-1 x MEX-142	25	Dimtu x SER-78
6	NASIR x SER-16	16	Awash-1 x VAX-3	26	Red wolayita x SER-176
7	NASIR x SEA-5	17	Cherchere x MEX-142	27	Red wolayita x SER-128
8	NASIR x BAT-477	18	Cherchere x VAX-3	28	Red wolayita x SER-78
9	NASIR x RAZ-44	19	Cherchere x BAT-477	29	Awash-1 x G 21212
10	NASIR x SER-176	20	Chore x SAB-712		

Technology generation

Mechanistic studies on drought resistance

Work at CIAT headquarters in Colombia involved both breeding in support of the program in Africa, and physiology work as a complement to breeding. At the outset of the TL II project, substantial progress had been made in improving the drought resistance of the small seeded Mesoamerican beans. This was carried out in part under a BMZ-Germany, funded project in which Nicaragua, Rwanda and Malawi participated. In 2009 and 2010, small red-seeded varieties with drought resistance were formally released from that effort in Rwanda and Nicaragua. The research in TL II built on that experience, and sought to extend it to the medium-to-large seeded beans of the Andean gene pool. Mechanisms being investigated involve both roots to access soil moisture, particularly from deeper soil layers, and remobilization of photosynthate to grain (partitioning of biomass).

<u>Studies on mechanisms of drought resistance</u>**:** We continued to evaluate a set of 36 elite lines in our drought season from June to September in CIAT-Colombia. Year to year rainfall variability created different patterns of drought stress, and over the past three years we have experienced light intermittent drought (2008), terminal drought (2009), and low rainfall that extended over much of the vegetative period (2010) (Figure 6-8). Each pattern of drought affected the crop response differently, and ranking of genotypes changed somewhat under different patterns (Table 6-20).

Light intermittent drought in 2008 resulted in very acceptable yields of drought-selected lines, although there were still wide differences in relation to the commercial check. Under terminal drought (2009), early materials ranked relatively better, as would be expected. These included SER 125 (released in Nicaragua), SER 16 (released in Rwanda), and G40001 (*Phaseolus acutifolius*). SER 78 was the highest yielder in 2009 and was mediocre in other years. In 2010 occasional but light rainfall during the vegetative phase of the crop resulted in more modest shoot development, and the ranking of some lines changed substantially. SXB 412 and SXB 405, both types developed for Brazil, and with adaptation to poor soil, ranked relatively better, whereas early materials were mid-to-low in ranking. This pattern of drought stress due to low rainfall during vegetative growth might have stimulated more early root growth in some genotypes, while the early materials did not benefit from this capacity. On the other hand, SXB 412 and SXB 405 were both mediocre under intermittent and terminal drought in 2008 and 2009, respectively.

A few entries, particularly black-seeded lines, were excellent under all patterns of drought, as well as with adequate soil moisture provided through irrigation. SEN 56 stood out among these. In spite of being relatively early to mature, it was the best line in 2010 when other early materials slipped in ranking. NCB 226 was especially noteworthy, since it was also one of the best lines under combined stress of low P and drought (see Table 6-20 below). Both lines have excellent remobilization of photosynthates to grain, a trait that is shared with SER 118 (small red) which was also very good in 2010, and has performed well under low soil fertility conditions. These observations bode well for the potential of developing varieties of common bean with multiple stress resistance. However, these results also indicate how complex the interactions of stress are on the crop. Plant responses to different types of stress may well be independent traits, and if this is the case, it appears that they can be recombined in lines such as NCB 226.

Correlations between yield and plant attributes under irrigated and rainfed conditions of the 36 lines varied somewhat from year to year, probably reflecting the different rainfall patterns in each year (Table 6-21). For example, days to flowering varied from -0.28 to -0.59, and leaf area index varied from -.09 to 0.44 in rainfed trials. However, pod harvest index (PHI) or the percent of pod biomass that is represented by seed weight, was the most consistently positive, and is a trait that should be considered as a selection criterion for breeding.

Table 6-20: Yield (kg per ha) of elite lines and checks under three patterns of drought and two seasons with irrigation. Patterns of drought included: light intermittent (2008); terminal (2009); and low rainfall throughout the vegetative cycle (2010).

Line/ check	Yield (kg per ha) under drought								Yield (kg per ha) under irrigation							
	2008	Rank	2009	Rank	2010	Rank	Ave.	Rank	2008	Rank	2009	Rank	2010	rank	Ave.	rank
SEN 56	2986	1	1236	9	2210	1	2144	1	2343	10	3358	2	4150	1	3284	2
NCB 226	2610	3	1381	4	2164	3	2052	2	2674	3	2989	9	3808	2	3157	3
NCB 280	2491	6	1403	2	2182	2	2025	3	2379	8	2702	17	3659	4	2914	8
SER 113	2606	4	1237	8	1682	12	1842	4	1960	14	3031	6	3607	5	2866	10
SEN 36	2188	10	1267	5	2034	4	1829	5	3059	1	3840	1	3345	14	3414	1
SEA 15	2077	15	1384	3	1800	6	1753	6	2196	11	2754	14	3363	11	2771	13
SER 125	2504	5	1266	6	1484	18	1751	7	1909	16	2836	11	2964	16	2570	16
SER 118	2161	12	1095	13	1980	5	1746	8	2148	12	3028	7	3311	15	2829	12
SER 109	2313	9	1208	11	1709	10	1743	9	2364	9	2761	13	3526	6	2884	9
SXB 415	2479	7	1108	12	1607	14	1731	10	2383	7	3262	4	3354	13	3000	7
SXB 418	2669	2	827	20	1649	13	1715	11	1637	20	2405	21	3375	10	2472	17
SER 78	2155	13	1489	1	1494	16	1713	12	1926	15	2735	15	2756	19	2472	18
SER 16	2330	8	1232	10	1558	15	1707	13	2517	5	3135	5	2842	18	2832	11
RCB 273	2171	11	942	16	1734	9	1616	14	2039	13	2662	18	3472	7	2724	14
SXB 412	1952	16	1031	14	1796	7	1593	15	2497	6	3300	3	3668	3	3155	4
SXB 405	1794	19	1015	15	1739	8	1516	16	2589	4	3017	8	3416	9	3007	6
BAT 477	1941	17	858	18	1691	11	1497	17	1904	17	2574	19	2670	20	2382	20
G 40001	1606	21	1257	7	1450	19	1438	18	1049	21	2547	20	2888	17	2161	21
DOR 390	2084	14	810	21	1322	20	1406	19	1689	19	2727	16	3362	12	2593	15
Carioca	1821	18	867	17	1492	17	1393	20	2855	2	2981	10	3444	8	3093	5
T. Canela	1786	20	827	19	1283	21	1299	21	1819	18	2788	12	2646	21	2418	19
LSD (0.05)	???	???	???	???	???	???	???	???	???	???	???	???	???	???	???	???

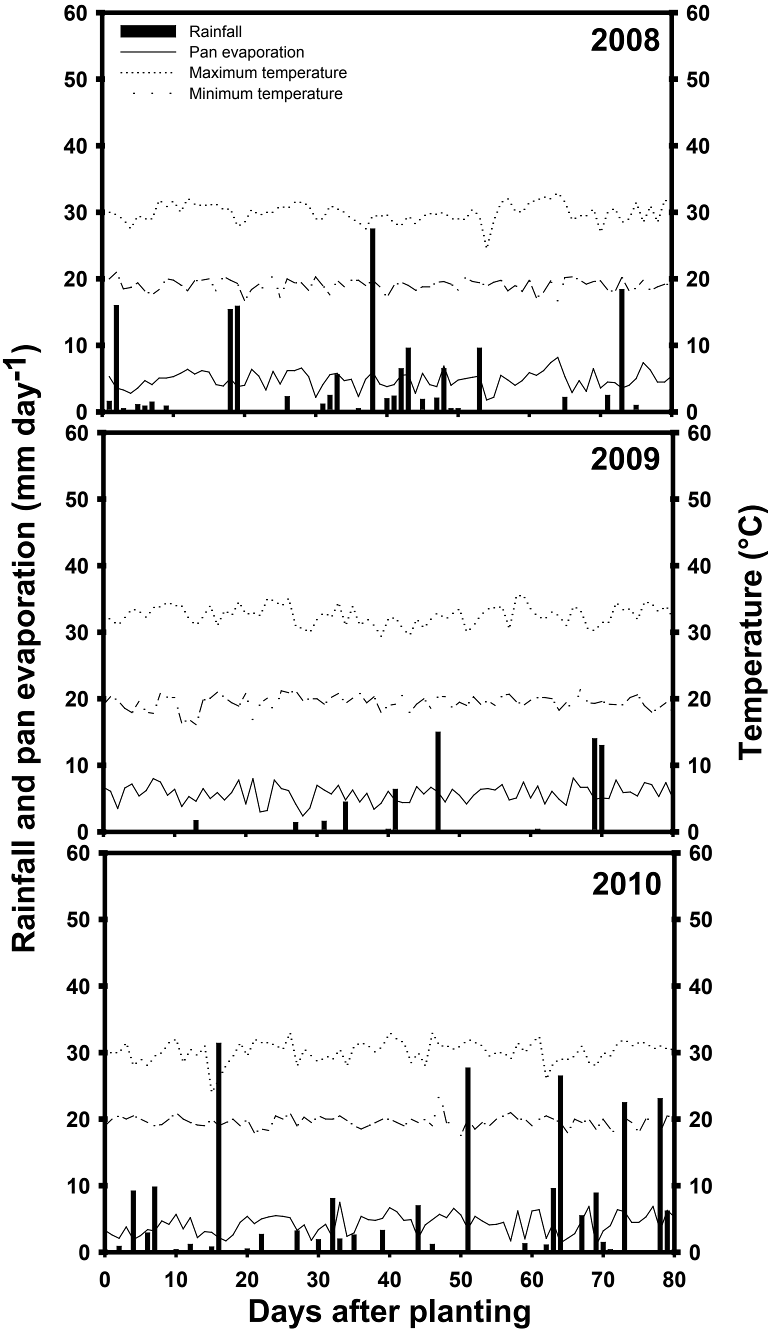


Figure 6-8: Rainfall distribution, pan evaporation, maximum and minimum temperatures during crop growing period at Palmira in 2008, 2009 and 2010.

During the crop-growing season, maximum and minimum air temperatures were 33°C and 16.6°C in 2008, 35.5°C and 16.1°C in 2009 and 33.0°C and 17.5°C in 2010, respectively. The incident solar radiation ranged from 9.1 to 23.6 MJ m-2 d-1 in 2008, 11.7 to 25.7 MJ m-2 d-1 in 2009 and 6.8 to 22.4 MJ m-2 d-1 in 2010. The total rainfall during the active crop growth was 161 mm in 2008, 59 mm in 2009 and 224 mm in 2010. The potential pan evaporation was of 393 mm in 2008, 462 mm in 2009 and 340 mm in 2010.

Table 6-21: Correlation coefficients (r) between final grain yield (kg per ha) and other plant attributes of 36 genotypes of common bean grown under irrigated and rainfed conditions in a Mollisol in Palmira, Colombia. Out of the 36 genotypes, 21 were common across three seasons.

Plant trait	2008		2009		2010		Average	
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
Leaf area index (m^2 m^{-2})	0.72***	0.35***	-0.25**	0.44***	0.04	0.09	0.56***	0.25***
Leaf chlorophyll content (SPAD)	0.10	0.24*	0.15	0.29**	0.17*	-0.006	-0.07	0.17*
Leaf stomatal conductance (mmol m^{-2} s^{-1})	0.15	0.24**	-0.01	0.04	0.10	0.21*	-0.01	0.22**
Canopy temperature depression (°C)	0.11	0.35***	0.12	0.25**	0.01	0.17	-0.25**	-0.10
Canopy biomass (kg per ha)	0.51***	0.19*	-0.02	0.59***	0.001	0.28	0.48***	0.10
Days to flowering	-0.18*	-0.36***	-0.38***	-0.59***	-0.05	-0.28**	-0.05	-0.10
Days to maturity	-0.01	-0.38***	-0.46***	-0.60***	-0.03	-0.21**	0.13	0.34***
Pod harvest index (%)	0.59***	0.58***	0.64***	0.61***	0.34***	0.48***	0.41***	0.44***
Pod partitioning index (%)	0.28**	0.42***	0.21*	0.56***	0.32***	0.006	0.20**	0.45***
Harvest index (%)	0.35***	0.47***	0.28**	0.61***	0.34***	0.05	0.24**	0.49***
100 seed weight (g)	0.53***	0.63***	0.62***	0.52***	0.23*	0.19*	-0.19**	0.63***
Pod number per m^2	0.25**	0.07	-0.35***	0.63***	0.04	0.01	0.36***	0.33***
Seed number per m^2	0.26**	-0.19	-0.49***	0.57***	0.12	0.1	0.33***	0.27***
Stem biomass reduction (%)	-0.33***	-0.15	0.17	-0.03	0.12	0.25**	-0.26***	0.19**

Interspecific crosses with tepary bean

Phaseolus acutifolius or tepary bean is a desert species with multiple drought resistance traits. It can be crossed with common bean only with great difficulty and using embryo rescue, but over several years of effort, we have accumulated a sizable number of interspecific progenies. The most drought resistant were identified and intercrossed, and selections from a second cycle were evaluated under terminal drought in 2009. A very unusual line, INB 841, was identified with high level of resistance to wilting, and unusually rapid pod development. Root evaluations suggest that the root system of this line is NOT superior, thus we suspect that it may possess possible mechanisms of stomatal regulation and/or osmotic adjustment to resist wilting. Its trait of rapid pod elongation may also be associated with hormonal regulation of pod growth and development. We are evaluating progenies of this line, which currently are in the F3 generation, to test empirically whether these traits could contribute to improving drought resistance in common bean.

Interspecific crosses with runner bean

As part of another BMZ project, combinations of drought resistance and aluminum (Al) tolerance were sought. Accessions of runner bean, or *Phaseolus coccineus*, proved to be highly resistant to Al, and were crossed to drought resistant line SER 16. This cross was designed to combine the vigor and biomass of runner bean with the remobilization capacity of SER 16. The resulting population was subjected to intensive study of root attributes, revealing large differences in rooting patterns and morphology that are relevant for improvement of common bean for drought resistance. Runner bean has a coarse, rugged root system with thick basal roots that can penetrate acid soil under drying conditions much better than common bean. Some lines from the runner bean source display less wilting. Some progenies of runner bean tend to produce large biomass and excellent yield potential, likely reflecting in part their vigorous root system, and we are using these lines as parents in combination with sources of enhanced photosynthate remobilization, for improved yields. This is still another source of traits that are being investigated as potentially relevant for drought resistance. Data presented in Table 6-22 represent yields under drought induced by limited water supply during the vegetative phase, followed by soil drying through much of the reproductive phase. All ALB lines are derived from the cross of runner bean with SER

16, and the advantage of some ALB lines over the SER 16 parent is due to introgression of genes and traits from runner bean.

Table 6-22: Yield under drought induced by low rainfall in the vegetative phase and post flower water deficit, of SER 16 and its ALB progenies derived from a cross with runner bean (Phaseolus coccineus) evaluated during the drought season in 2010.

Line	Yield (kg per ha)	Line	Yield (kg per ha)
ALB 60	2155	ALB 147	1618
ALB 180	1908	ALB 77	1565
ALB 213	1830	SER 16	1558
ALB 209	1826	ALB 110	1312
ALB 214	1734	TIO CANELA 75	1283
ALB 91	1713	LDS (0.05)	436
ALB 6	1631		

An ideotype for Mesoamerican beans

Beans are often planted in marginal soils, and Mesoamerican beans in particular often occupy the more difficult niches, even within a farm. Soil fertility is a critical issue for the improvement of bean yields, and poor fertility will often override the benefits of drought resistance. Beans are relatively sensitive to poor fertility compared to other legumes, in part due to their short growth cycle that is often less than 80 days. Our experience over many years has shown that rusticity and yield in poor soil are greatly affected by phenology. In one such experience a trial of drought resistant lines was planted for evaluation of response to low soil P availability and unexpectedly suffered severe midseason drought. The better yielding lines tended to be later flowering while the grain filling period was not noticeably different (Table 6-23). We believe that the ability to withstand low fertility permits overall plant vigor and probably root development, and contributes to drought resistance.

A short season crop does not have sufficient time to explore the soil profile, but on the other hand, farmers also prefer early varieties of bean. This presents a contradiction that demands a new ideotype that is rustic and yet not late-maturing. We suggest that such an ideotype would have an extended vegetative period to permit better root development, better plant nutrition and greater biomass production, followed by a reproductive phase characterized by aggressive remobilization and rapid dry down at maturity. Experience gained in characterization of remobilization in TL II makes us hopeful that this is possible. In particular, one red seeded line, SER 118, is consistently superior in pod harvest index (a measure of remobilization), and tends to present this pattern of mid-late flowering and acceptable maturity. It often yields among the best lines. We hope to build on this pattern with genetic variability of several sources.

Table 6-23: The four highest yielding entries, and the four lowest yielding entries out of 36 drought-resistant lines and checks subjected to combined stress of low available soil phosphorus and mid-season drought. Darién, Colombia, 2009.

Line	Yield (kg per ha)	Days to flowering	Days to grain filling
SXB 412	1257	41	38
NCB 226	1206	33	41
SXB 409	1187	40	42
SXB 405	1175	39	40
SEA 15	625	34	43
SEN 56	563	32	43
SEA 5	379	34	39
G 40001-*P. acutifolius*	190	37	39
LSD (0.05)	266	2.5	???

Applying physiological principles to breeding beans of the Andean gene pool

Historically, progress in improving Andean beans tends to be slower than for Mesoamerican beans. On one hand, grain of Andeans is larger with very specific criteria of size, shape and color, such that recovering commercial grain in segregating populations is more difficult. This makes introgression of novel genes more laborious. On the other hand, most Andean-type varieties are of determinate growth habit, which limits yield potential to some degree. In spite of this, our first efforts in improving Andean beans for drought resistance were quite positive. Selected lines expressed excellent grain filling under stress, suggesting enhanced remobilization to grain. Although expressing a yield advantage over checks in optimal conditions of soil fertility, these lines were excessively early and poor yielding under more realistic conditions of low to moderate fertility. Thus, Andean beans presented the same pattern as Mesoamerican types. We immediately adjusted the breeding program to include parents with a longer growth cycle and adaptation to poor soil, especially the cultivar CAL 143 from southern Africa. Results with selections under drought have been excellent (Table 6-24). Among the parental materials in the crosses represented in Table 24, CAL 143, KAT B1 and PAN 127 are commercial varieties in Africa, and the last column of the table represents their respective yields. Yields of their progenies are far superior to the yields of the parents. These lines were selected under moderately low fertility in the F3 generation, and tests of the lines in low soil fertility are pending.

Table 6-24: Yield (kg per ha) of elite lines of the Andean gene pool, evaluated under terminal drought in 2009.

Line	Yield (kg per ha)	Commercial check (kg per ha)
(CAL 143 x SAB 616) X SAB 629	1857	363
(CAL 143 x SAB 620) X SAB 626	1880	363
(CAL 143 x SAB 620) X SAB 626	1930	568
(KAT B1 x SAB 618) X (SAB 620xSAB 631)	1962	1222
(KAT B1 x SAB 618) X (SAB 623xSAB 627)	1882	1561
(SAB 630 x PAN 127) X SAB 676	1976	18

Human capacity building

Our goal was to establish within the PABRA network a working group with expertise in drought research. While formal degree training formed a part of this plan, an equally important part dealt with obtaining skills of field management and physiological analysis. All progress in abiotic stress resistance, and especially in drought resistance, must depend on reliable field evaluation. This applies as well to prospects for marker assisted selection, which must initiate with reliable phenotypic data. Trials for managed drought must incorporate calibration of drought stress, starting with quantification of the amount of moisture in the soil. While scientists must understand principles, they must also appreciate the methods and logistics of field management, to be able to supervise effective field research. Technicians must be fully capable of executing field studies, assuring uniformity across the field, and mastering the logistics of field work (e.g., physiological sampling) so that this is carried out efficiently and with minimum errors. Often the technicians are the most stable element within a research program, as scientists must dedicate time to administrative duties. Thus, in addition to formal degree training, we also made an effort to establish capacity in the region among both scientists and technicians, for practical field oriented drought research. Practical skills included: quantification of soil moisture content; sampling of field grown plants; distribution of plant biomass in different plant parts; biomass drying; data analysis.

Two field workshops were held, in January 2008 in Katumani, and May 2008 in Malawi. Additionally, a physiology assistant from CIAT-Colombia visited each participating country to supervise work on site, and to give advice on phenotyping protocols and data analysis.

Number of degree training students (MSc, PhD) completed or ongoing

Our original milestone called for two PhD candidates to advance in their studies and two MSc candidates to complete their degrees. In addition to this, it was possible to give partial operational support to two other students, only one of whom finished his degree. At one time we saw the opportunity to stretch funding to include another PhD candidate in place of one of the MSc candidates, but that person withdrew his candidacy when an opportunity arose to study in New Zealand, and the funding was used for an MSc as originally planned. Degree training proved to be an excellent bridge between the TL I and TL II projects, as several theses were derived from topics directly from TL I , or closely akin to themes developed there.

Degree training: scholarships

Berhanu Amsalu of EIAR, Melkassa Research Center in Nazareth, Ethiopia is in his last year of PhD study at the University of Pretoria, Republic of South Africa, with expectations to finish in late 2011. Berhanu is studying aspects of nitrogen fixation in common bean under drought, looking at the activity of protease inhibitors as indicators of nodule health. It is known that as legumes come under stress, nodules degrade under the influence of proteases that break down proteins including nitrogenase. Lower protease activity (or conversely, more activity of protease inhibitors) could be an indicator of nodule health, especially under stress when fixation tends to decline. Berhanu initiated with a greenhouse study of soybean (thus, his thesis and his results could eventually be relevant for BNF of soybean under stress as well). Subsequently Berhanu continued greenhouse studies on common bean with the high nitrogen fixing line BAT 477, the poor fixer DOR 364, and their progenies. He also carried out a field trial with the same genotypes. Finally he executed a trial looking at the interaction of drought x P levels, under the hypothesis that the protease degradation of nodules is a generalized mechanism in response to stress, and that BAT 477 will show low activity of proteases under both moisture stress and low P stress. He currently is assaying protease activity to test this hypothesis.

Godwill Makunde of Zimbabwe is completing one more cycle of field work in his home country, and then will return to Free State University, RSA, to analyze his data and to write his thesis. He should be finishing toward the end of 2011. His university expenses have been financed by TL-II, and his research has been supported mostly by TL-I. His research involves a physiological analysis of the TL I reference collection, which is a sub-set of 202 accessions from the CIAT core collection, re-selected based on detailed molecular analysis and employing a more focused attention on race Durango from Mexico, and on Andean types. These two groups were emphasized with the philosophy that race Durango might yield new sources of drought resistance, and the Andean types were those that were most in need of improvement, and that it would be useful to take advantage of whatever variability that exists among the Andeans. Godwill will have two seasons' data from Zimbabwe, and three seasons' data from Colombia under varying degrees of moisture stress. Godwill himself executed the physiological sampling and analysis of the reference collection in CIAT-Colombia under intense terminal stress. He also conducted root phenotyping studies at CIAT-Colombia on selected genotypes from the reference collection. With data from several sites and seasons, Godwill will perform an analysis of association mapping using SNP data generated at UC-Davis in the group of Doug Cook. This will be the first such attempt in common bean.

Felix Waweru graduated from the University of Nairobi, Kenya with an MSc degree in a study shared with TL I. Felix carried out a field phenotyping of recombinant inbred lines (RILs) of a cross of BAT 881 x G21212. BAT 881 is sensitive to abiotic stress, and G21212 is relatively resistant. G21212 was first recognized as tolerant to low soil P, and subsequently it also proved to have a good response to drought and aluminum toxicity. It presents excellent remobilization of photosynthate to grain under stress, and this appears to be its mechanism of multiple stress resistance. A genetic map exists for this population, and the data of Felix could help elucidate the inheritance of this trait. Felix also analyzed a regional collection of landraces and lines, compiled under TL I.

Lizzie Kalolokesya of Malawi completed an MSc degree at the University of Zambia. Lizzie was brought on board when Isaac Fandika withdrew to study in New Zealand. Lizzie carried out marker assisted selection (MAS) for disease resistance in collaboration with TL I . Lizzie had the opportunity to carry our part of her research in the installations of ARC-Potchefstroom in South Africa, broadening her perspectives and working in collaboration with an on-going practical breeding program.

Degree training: operational support

Teshale Assefa, formerly of EIAR, Melkassa, Ethiopia, completed his PhD degree at the University of Padua in Italy. Teshale worked on drought tolerance and canning quality of navy beans, analyzing recombinant inbred lines (RIL) of the cross SXB 405 x ICA Bunsi developed in CIAT. The former is a rustic, low fertility tolerant line developed for drought tolerance. The latter is a small white canning type developed many years ago in the national bean program of Colombia. Teshale selected 78 lines based on grain type and planted these under managed drought and irrigated conditions in Melkassa Station. A physiological analysis showed that the parameters of biomass accumulation and pod harvest index both contributed to final yield, again validating the role of remobilization of photosynthate to grain as an important drought resistance mechanism. Teshale also involved farmers and traders in the evaluation process, bringing farmers on station for this activity. Finally, an evaluation of canning quality was carried out on 8 elite lines, with the result that most lines were found to be acceptable, and one of the most drought resistant lines was also rated excellent in canning quality. Lines will be distributed throughout the region for evaluation by other partner countries. Teshale also received training in CIAT-Colombia in evaluation of bruchid resistance.

Susan Gachanja received support toward her MSc degree research at the University of Nairobi. Susan worked on the physiological analysis of the fast track nursery. Unfortunately Susan left her studies before finishing her degree.

Number of NARS scientists trained

Table 6-25: National program scientists trained under the TL II project.

Country	Last name	First name	Gender	Position	Institute
Ethiopia	Amsalu	Berhanu	Male	Agronomist	EIAR
	Gebeyehu	Setegn	Male	Research Physiologist	EIAR
Kenya	Gachanja	Susan		Student	University of Nairobi
	Musyoki	Robert	Male	Researcher biotechnologist	Kenya Seed Company
	Okwuosa	Elizabeth	Female	Researcher Breeder	KARI
	Wachira	Geofrey	Male	Research Assistant	University of Nairobi
	Macharia	David	Male	Researcher Breeder	KARI
Malawi	Fandika	Isaac	Male	Research Agronomist/Physiologist	DAR
	Kalolokesya	Lizzie	Female	Research Assistant	CIAT - Chitedze Research Station
	Chisale	Virginia	Female	Breeder	DAR
Tanzania	Msaky	John	Male	Agronomist	SARI
	Slumpa	Simon	Male	Research entomologist	SARI
	Kweka	S.O.	Male	Breeder	SARI
Zimbabwe	Makunde	Godwill	Male	Researcher/Breeder	Crop Breeding Institute

Number of NARS technicians trained

Table 6-26: National program technicians trained under the TL IIproject.

Country	Last Name	First name	Gender	Position	Institute
Ethiopia	Lemlem	Micheal	Male	Technician	EIAR/MARC
	Jemal	Abdulshikur	Male	Technician	EIAR
	Dagne	Belete	Male	Technician	EIAR
Kenya	Mutinda	Duncan	Male	Technician	KAR
	Mwangi	John	Male	Technician	University of Nairobi
Malawi	Banda	Raphael	Male	Technician	DAR-Kasinthula
	Ngwira	Evelyn	Female	Technician	DAR
	Chibwana	Willard	Male	Technician	DAR
Rwanda	Mukankubana	Domitilla	Female	Technician	ISAR
	Gasigwa	Evariste	Male	Technician	ISAR
Tanzania	Kisamo	Alex	Male	Technician	SARI
	Mawalla	Rogast S.	Male	Technician	SARI
Zimbabwe	Mudzamiri	Clemence	Male	Technician	Research and Specialist Services
	Gachange	N.	Male	Technician	University of Zimbabwe
	Mudzamiri	Clemence	Male	Technician	Research and Specialist Services

Training of trainers and farmers sessions

Training of trainer (ToT) sessions have been held across the two countries. In Kenya, the training was of staff members of partners organizations (22) were carried out by KARI and KEPHIS. While in Ethiopia, the training was mainly carried out by EIAR-Melkassa and SARI-Hawassa especially targeting district agricultural officers, staff members from the partners NGOs and representatives of the Farmers' Cooperative Unions. In total, 549 trainers were trained on bean pre and post harvest management, specific seed quality instruction; initiation to agri-business skills and group leadership and dynamism. The trainees also were able to train 35943 farmers of whom 49.73% (see Table 6-27). In addition to training, partner organizations organized demonstrations and seed fairs which were attended by 54733 farmers whose 43.19 % were women (see Table 6-30). The demos and seed fairs were carried out to popularize the new varieties and also to allow seed access through local and affordable means (exchanges and purchase).

Table 6-27: Number of trainers and farmers trained between 2008 and 2010

County	Number of trainers trained	Number of farmers trained	
		Women	Men
Ethiopia	350	1,787	6,654
Kenya	189	16,090	11,412
		17,877	18,066
Total	**549**	**35,943**	

Table 6-28: Attendance of demonstration and seed fairs

County	Number of demos/seed fairs	Number of farmers attending	
		Women	Men
Ethiopia	45	1,359	12,890
Kenya	148	22,383	18,201
		23,642	31,091
Total	**193**	**54,733**	

Infrastructural capacity building

Equipment purchased and delivered

Table 6-29: Equipment purchased for national research programs under the TL II project

Equipment	Countries
Davis Vantage Pro2 Weather Station.	ETH, KYA, MWI, TNZ, ZIM
Laptop computer	" "
Watermark soil moisture system with Meters.	" "
Sensor for Soil moisture system.	" "
Ohaus Explorer Pro Toploading Balance.	" "
Ohaus Explorer Pro Toploading Balance.	" "
Digital camera SONY DSC-H50/B	" "
ET Gauge	" "
SPAD 502DL Chlorophyll meter	" "
Soil Corers	" "
SC-1 Porometer	ETH, KYA, MWI
Turf-Tec Infrared Turf Thermometer with probe	" "
Hand-held FluorPen with firmware upgrade	" "
WHINRIZO Prosoftware on CDROM	" "
Calibrate Color Optical Scanner	" "
Root positioning system for STD scanners	" "

Facilities installed or upgraded

Site descriptions and recommendations

At the initiation of the TL II project, a consultant was contracted to review the state of infrastructure and the suitability of experiment stations for drought research. Site visits were carried out at:

- Melkassa, Ethiopia
- Thika, Kenya
- Kabete, Kenya
- Katumani, Kenya
- Kiboko, Kenya
- Kandiyani, Malawi
- Kasinthula, Malawi
- Chiredzi, Zimbabwe
- Selian, Tanzania
- Madiira, Tanzania

Sites were evaluated for water quality, soil water holding capacity, existence and/or state of irrigation facilities, weather patterns and implications for planting dates. A report of his study is available, and in Phase 2 of TL II, we will refer back to this study and its recommendations, to continue to improve accuracy and relevance of drought research.

Installation of an irrigation system in Selian Research Station, Arusha, Tanzania

While equipment was offered to all programs, in the second year the Bean Program of Selian elected to forego more equipment purchase in favor of obtaining an irrigation system to facilitate managed drought nurseries, using an existing bore hole as a source of water. Options were studied, and a solar-powered pumping system was purchased as a more economical mode than tapping the local energy network (which would have been the most costly part of the installation!). The system was installed only to discover that the bore hole at the site had not been properly drilled, and did not reach the water table. An appeal was made to central authorities for additional funds to remake the bore hole, and it appears that soon the system should be functional.

Rain-out shelter in CIAT-Colombia

To facilitate more detailed and controlled physiological studies, and confirm results under field conditions where control of moisture is less precise, a rain out shelter was established at CIAT headquarters.

Development of information tools: videos and training manuals

Several videos were also developed specifically to extend awareness of the use and possible impacts of packing and marketing seed in small packs (from 100 g to 2 kg packages). These have been made in different lengths for partners (3 minute 20) and possible TV use (30 second). Further, while a first video centers on experience in the initial small pack test country, Kenya, another portrays experience to include both TL II-linked and other PABRA countries (Ethiopia, plus Malawi, Congo and Tanzania). Finally, small pack videos have been made in English and more recently in French. These videos, as awareness-raising tools, have proven very powerful in stimulating NARS, private sector companies NGOs, and other organizations to consider small seed pack marketing so as to scale up their business and Training manuals also reach more clientele.

In the two countries, variety, seed-related information tools and booklets (on production and post harvest handling) have also been developed in local languages, targeting farmers with various levels of literacy, traders and extension staff. In Ethiopia, 7954 variety description leaflets, 2486 seed production guides and 2790 varieties poster targeting mainly illiterate farmers were produced and supplied. In Kenya, 1200 production guides (brochures) and 680 posters of varieties were supplied during seed fairs and demos.

Vision

From the phase 1 research, it became clear that target strategies are required along the value chain to address the problem of drought, declining soil fertility, constraints in seed and grain markets. Such investments are inter-related and therefore all are required to achieve a combined effect. In other words, germplasm improvement, management practices/ extension and marketing need to be addressed in order to achieve maximum beneficial and equitable impacts.

Germplasm improvement to address drought

In the course of the phase 1, drought research has been firmly established as a research priority within PABRA on all levels. Field testing is now practiced routinely. Improved lines are in the pipeline. Equipment is in place for more detailed evaluations. In collaboration with TL-I, scientific capacity has been enhanced through post-graduate training. For phase 2 we look to expand the reach of TL-II's impact by involving other partner countries within PABRA, and to focus on the enhanced capacity on understanding G x E within drought trials, in conjunction with TL-I. Breeding will continue to address both terminal and intermittent types of drought, while minimizing trade-offs between large harvests and good culinary traits or marketability. Important culinary traits (e.g less cooking, low flatulence, keeping quality or taste) and market preferences (e.g seed shape and color) in Ethiopia were indentified from baseline studies. Currently, seed color and seed shape are the key attributes used in grading beans on the market for export in Ethiopia and they are likely to become more important determinants of variety choice by farmers in the near future while the existing varieties with flat shape or less brilliant color could be dis-adopted.

Soil fertility

Soil fertility is clearly a major confounding factor in the evaluation of drought lines and we must attend to this factor in complementary fashion – exploiting both genetic and crop management techniques – to assure that drought tolerance is fully expressed. There is need in Phase 2 to expand beyond varietal introductions — focus on fertilizer associated with specialized seed production. Simply, soil fertility improvement is key for all zones, and especially stressed ones. N fixation, moderate use of P, manures (green and organic) might all be themes to be pursued (in conjunction with the use of drought-tolerant varieties). More comprehensive links with the BMGF-N2Africa should be sought quickly and across multiple countries.

Pests and diseases

Other production constraints in drought-prone zones are associated with pests and diseases. BSM, *Macrophomina,* CBB, BCMV and aphids (etc.) are all important disease and pest constraints facing drought-prone zones. Lessening their effects can help stabilize and increase production. TL II in Phase 2 will link up with the ongoing integrated pest and disease management research under PABRA to integrate good practices in managing these constraints. Molecular markers for CBB and *Zabrotes* will be extended to the routine breeding program. This will permit focusing even more intensely on the difficult abiotic stresses that are a much bigger challenge. The prospects of effective implementation of marker assisted selection for drought per se will continue to depend on obtaining relevant and reliable phenotypic data. In this regard, TL II will have made a significant contribution to TL I , by strengthening the field component of drought work.

Seed Production and Delivery Systems

Similarly, the advance in exploiting novel seed systems is putting clichés about "legume seed systems don't work" on their head. Two models – the small pack strategy and the seed loan system – were especially successful and should be tested in other settings. While all targets have been met, demand is sharply rising for the drought-tolerant varieties. More organizations and a more diversified set of partners need to be brought into this arena of high quality seed production. The concerns are to: increase overall quantity, ensure more stabilized production and diversify risks (including risks of seed being usurped for relief efforts or political campaigns).

In the first phase of TL II, bean seed systems have been characterized by a multitude of partners. The truly 'best bet' modes of operating now need to be promoted (those which are sustainable, producing high volumes—and which can reach all in drought-prone zones). The number of seed production models will be reduced and focus put on 'best bet' decentralized production modes. This also applies to the methods used for demand creation and awareness raising - to professionalize such demand creation and outreach. Small pack approach is a true win-win–win —for the public sector, private sector—and for farmers. It has to quickly move beyond "test experiments" to large scale institutionalization. The challenges will be the unavailability of certified seeds which can be packed. Without certified/NARS seed supply, the small packs approach may be difficult to use at large scale!!

The private sector and an expanded network of agro-dealers and other outlets need to be engaged. Focused research might best be conducted of sizes and cross-crop combinations. Legume seed production will likely be sustainable most readily if this is implemented across crops—where new and desired varieties are rolled out on a continuing basis. Cross-crop marketing and awareness-raising can only benefit service providers as well as farmers. There is, therefore, the need to promote cross-legume research, production, marketing and awareness-raising.

Legumes in many countries are principally associated with women (that is, until the profits roll in). In Phase 1, the TL II bean seed system tried to increase chances of women farmers' participation especially in training and field days/seed fairs. The promotion of the use of small packs and local seed systems tended to benefit women more than men especially in Kenya. A lot more still needs to be done in Phase 2 to strengthen gender as a true core value and and implement the gender strategy of TL II.

Impact assessment and enhancement

Phase II will also be the opportunity to expand the preliminary impact work initiated in phase I, and to start to quantify the benefits in terms of welfare and yield stability. Research and development interventions to improve market coordination along the value chain will help reduce problems identified in the baseline studies that reduce farmers' access to profitable markets and could enhance incomes from legumes. For example, value chain actors need to access information and skills on improved post harvest handling practices that add value (such as cleaning, sort, grading, and standardization) -- to reduce transaction costs. Such interventions should be guided by focused research to be able to weigh the chances and degree of success and contribution it will make before huge sums of money are invested.

Annexes

Annex 6-1: Selected variety morphological characteristics, their local names, incidences and area share among the sampled households in Eastern Kenya and Ethiopia

Variety local Name (s)	Researcher classification	Morphological characteristics	Year of Release/ Origin	Household share (%)	Average area share (%)
		Eastern Kenya			
Nyayo or maina	GLP2	Large red mottled	Early 1980s	71.5	25.56
Amini	GLP2	Very large red mottled		4.9	1.75
Rosecoco	GLP2	Medium Purple mottled	Early 1980s	13.8	2.25
Nyayo short, saitoti or short maina	GLP2	Medium size red mottled on white		17.9	4.84
Kakunzu	Local	Purple stripes on cream		8.9	0.05
Mwezimoja	GLP1127/ GLP1004	Medium purple or grey speckled	Early 1980s (Kenyan land race)	7.3	1.57
Katumbuka, Mwitemania, Katinga or maddu	GLPX92	Medium Pinto	Early 1980s (Kenyan land race)	87.0	48.40
Wairimu, Katune or Kamusina	GLP585	Small red haricot	Early 1980s	12.2	2.99
Kitui	GLp24	Large dark red kidney	Pre-released 1993	14.6	2.76
Kitui Small;	GLP24	Small dark red kidney	-	-	-
Kayellow, Kathika, or Ka-green	KatB1	Medium yellow/green round shaped	Pre-released 1985	34.6	8.12
Kaselu or kelu	Mexican 142	White haricots			0.00
Ikoso, Ngoloso or Itulenge	Local	Black with white stripes		15.5	1.86
Kamwithiokya	Local	Black			0.01
Kavuti	Local	-			
Kasanzai	Local	-			
Kanacy	Local	-			
		Central Rift valley (Ethiopia)			
Mex-142	Improved	Good canning quality	1972	64.4	50.17
Awash –1	Improved	Small white canning type	1990	22.6	10.43
Unspecified Limat	Improved			6.03	4.63
Awash-Melka	Improved	Good canning quality and Anth. Tolerant	1999	22.4	10.43
Argane	Improved	Good canning quality	2005	17.2	11.59
Bora	Local			23.5	4.63
Roba -1	Improved	High yield, good for shiro & kik	1990	6.0	4.63
Red Wolaita	Local	Adaptation to all part of the country & preferred color	1974	20.7	3.48
		SNNPR (Southern Ethiopia)			
Mex-142	Improved	Good canning quality	1972	6.7	2.93
Awash –1	Improved	Good canning quality and high yield	1990	3.8	8.02
Red Wolaita	Local	Adaptation to all parts of the country & preferred color	1974	86.7	69.52
Naser	Improved	High yield & early	2003	4.8	1.07
Ibado	Improved	-		2.9	0.80
Brown beans	Local	-		4.8	0.53
White beans		-		13.3	2.67
Logoma	Local			4.8	1.07
Wakadima	Local			8.6	13.37

Source: Awassa and Melkassa monitoring and evaluation tool 2005, updated with survey data

Annex 6-2: TL IIEthiopia: decentralized seed production, Phase 1

Ethiopia: Overall decentralized seed production

EIAR	Year	Quantity (MT)	Multiplication Rate	% Harvest used as seed	Seed produced (MT)
Foundation Seed	2008	44.30	10	67	296.81
	2009	296.80	10	30	890.40
	2010	890.40	10	30	2671.20
Sub Total					3858.41
Foundation Seed	2009	34.55	10	67	231.49
	2010	231.48	10	30	694.44
Sub Total					925.93
Foundation Seed	2010	28.30	10	67	189.61
Sub Total					189.61
EIAR Total					4973.95

SARI		Quantity (MT)	Multiplication rate	% Harvest used as Seed	Seed Produced (MT)
Foundation Seed	2008	5.85	10	67	39.20
	2009	39.20	10	30	117.59
	2010	117.59	10	30	352.76
Sub Total					**509.54**
Foundation Seed	2009	61.50	10	67	412.05
	2010	412.00	10	30	1236.00
Sub Total					**1648.05**
	2010	70.10	10	67	469.67
SARI Total					**2,627.26**
Small packs total (part b)					178.66

Overall Total (Small packs+ seed with partners EIAR+ SARI)					7,779.86

b. Ethiopia Small packs: amount of seed produced

Year		Qty (MT)	Multiplication rate	% Harvest used as Seed	Total Seed Produced (MT)
Cycle 1	2008	None			
Cycle 2	2009	11.118	10	30	33.354
	2010	33.354	10	30	100.062
Sub Total					**133.416**
Cycle 3	2010	15.02	10	30	45.06
Total					**178.476**

Assumptions (based on field data):
Farmers' cooperatives recover 67% of harvest as seed.
Non-specialist farmers- recover 30% of harvest as seed - subsequent years

Annex 6-3: Ethiopia bean seed systems: people reached, TL II Phase I

A. Regular seed produced (not small packs)

EIAR	Direct reach	Seed (MT)	Direct Reach				indirect –sharing	
cycle 1	Year		Farmers bought/ received avrg 25kg	70% gave first season	Year		Group 1	Group 2
	2008	296.81	11,872.00	8,310.40				
					2009		8,310.40	
					2010		16,620.80	5,817.30
	2009	890.4	35,616.00	24,931.20				
					2010		24,931.20	
	2010	2671.2	106,848.00	74,793.60				
cycle 2	2009	231.49	9,259.60	6,481.72				
					2010	15,432.67	6,481.72	
	2010	694.44	27,777.60	19,444.32				
cycle 3	2010	189.61	7,484.00	5,238.80				
EIAR TOTAL- not small packs				139,200.04			56,344.12	5,817.30
Total Farmers reached EIAR								201,361.46
SARI	Year	Seed	Farmers bought/ Received average 25kg	70% gave first season	Year		grp1	grp2
cycle 1	2008	39.2	1,568.00	1,097.60				
					2009		1,097.60	
					2010		2,195.20	
	2009	117.59	4,703.60	3,292.52				
					2010		3,292.52	
	2010	352.76	14,110.40	9,877.28				
cycle 2	2009	412.05	16,482.00	11,537.40				
					2010	27,470	11,537.40	
	2010	1236	49,440.00	34,608.00				
cycle 3	2010	469.67	18,786.00	13,150.20				
SARI total not small packs				73,563.00			18,122.72	0
Total Farmers SARI								**91,685.72**
Small packs		**Seed**						
				People/1 kg				
	2009	33.354		33,354				
					2010/70%	23,347.80		
	2010	100.06		100,062				
	2010	15.02		15,020				
total small packs				**148,436**		**23,347.80**		
Total farmers reached by small packs								**171783.8**
Total Ethiopia EIAR and SARI-- All Means								**464,830.98**

Assumptions:

1. Farmers on average bought/received 25 kg
2. For small packs average of 500g (this comes from initial years of handing out 20-50 kg, then handing out 10, 25 kg - which emphasis on first)
3. Sharing, after first year 1, second year 2, third year 3
4. Only 70% give the first season

Based on seed production figures generated 28 March 2011 by the PABRA team.

Chickpea Improvement in India: Baseline, Breeding and Seed Systems

Pooran Gaur, CLL Gowda, ShaileshTripathi, Arvaind Jukanti, Suresh Pande, HC Sharma, Vincent Vadez, L Krishnamurthy, GV Ranga Rao, Rajeev Varshney, MCS Bantilan, P Parthasarathy Rao, GD Nageswara Rao, R Padmaja (ICRISAT-Patancheru, India); V Jayalakshmi, Y Satish, Y Koteshwar Rao, ATrivikrama Reddy, P Muniratnam, K Suhasini (ANGRAU, Hyderabad); PM Salimath, GN Kulkarni, VR Kiresur (UAS-Dharwad); DM Mannur (UAS-Raichur); with National Seed Corporation (NSC), State Farms Corporation of India Limited (SFCI), Andhra Pradesh State Seed Development Corporation (APSSDC), Karnataka State Seed Corporation (KSSC)

Summary

The chickpea activities were conducted in Andhra Pradesh (Kurnool and Prakasam districts) and Karnataka (Dharwad and Gulbarga districts) states of India. The project partners include ICRISAT-Patancheru; Acharya NG Ranga Agricultural University (ANGRAU), Hyderabad, Andhra Pradesh; University of Agricultural Sciences, Dharwad (UAS-D), Karnataka; University of Agricultural Sciences, Raichur (UAS-R), Karnataka; National Seed Corporation (NSC), State Farms Corporation of India Limited (SFCI), Andhra Pradesh State Seed Development Corporation (APSSDC) and Karnataka State Seed Corporation (KSSC).

The current status of adoption of improved varieties and traits preferred by the farmers were assessed during a regional work planning meeting organized at ICRISAT-Patancheru at the beginning of the project. Considering the requirements of target regions, the chickpea improvement program was focused on developing breeding lines with high yield potential, early maturity, high resistance to *Fusarium* wilt and market-preferred seed traits. ICRISAT supplied over 200 lines (117 desi + 92 kabuli) to NARS partners in India and ESA. Early generation breeding materials were developed for resistance to *Helicoverpa* pod borer through interspecific hybridization and promising lines have been identified. The research team engaged in chickpea improvement activities of TL II and TL I projects was the same and thus there was a good integration of research inputs and outputs between these two projects. Marker-assisted backcross lines developed under TL I project have been distributed to TL II partners for evaluation.

Earlier studies indicated that adoption of improved chickpea varieties continued to remain low in TL II target countries. Unawareness of farmers about the improved varieties and/or their useful traits and inadequate availability of seed of improved varieties were among the major factors for poor adoption of varieties. Farmer-participatory varietal selection (PVS) trials were conducted for exposing farmers to improved varieties and allowing them to select varieties of their preference. The most preferred varieties identified were JG 11, JAKI 9218 and JG 130 in Kurnool district; JG 11, JAKI 9218, JG 130 and KAK 2 in Prakasam district; and JG 11, BGD 103, JAKI 9218 and MNK 1 in Dharwad and Gulbarga districts. The traits for which these varieties were preferred included, profuse podding, high productivity, early maturity, resistance to *Fusarium* wilt, and market-preferred seed traits (e.g. medium seed size in desi type and large seed size in kabuli type). All varieties included in the PVS trials were released varieties, except BGD 102 and MNK 1 which were elite lines at pre-release stage. The results of PVS trials strengthened release proposals of BGD 103 and MNK 1 and these were released in 2009 and 2010, respectively.

Seed availability at local level is being enhanced by strengthening the formal as well as informal seed production chain. During the past four years (2007/08 to 2010/11) a total of 1,207 MT Breeder Seed and 886 MT Certified and Truthfully LabeledS of farmer preferred improved chickpea varieties was produced by research partners. Close to 5,000 seed samples (2 kg to 20 kg) were also distributed to

farmers for enhancing their awareness about improved varieties. Various awareness activities created high demand of seed for farmer-preferred varieties. The public seed corporations (NSC, SFCI, APSSDC and KSSC) joined hands with research partners and produced 70,607 MT Certified Seed and 3,924 MT Foundation Seed. JG 11 was the most popular variety with 85% share in Certified Seed.

Under capacity building, training on various aspects of improved crop and seed production technologies of chickpea was provided to 12,000 (10,842 men + 1,158 women) farmers and 1,411 extension personnel (1,229 men + 182 women). A total of 48 field days and 10 farmer's fairs were organized in which about 27,000 farmers (24,290 men + 2,697 women) participated. Efforts were made to reach large number of farmers through electronic and print media to disseminate information on improved varieties and crop production technologies.

Efforts were also made to enhance capacity of NARS in chickpea improvement and seed production. Two one-month training courses on "Chickpea Breeding and Seed Production" were organized at ICRISAT-Patancheru in which 12 researchers (9 men + 3 women) from the NARS of Ethiopia, Tanzania and Kenya participated. The infrastructure facilities for seed production, processing and storage were strengthened at research stations. One PhD student from India and one MSc student each from Kenya and Ethiopia completed part of their theses research on chickpea at ICRISAT-Patancheru.

Introduction

Chickpea (*Cicer arietinum* L.) also called Bengal gram or Garbanzo, is the largest produced food legume in South Asia and the third largest produced food legume globally, after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisumsativum*L.). Chickpea is grown in more than 50 countries (90% area in Asia, 4.7% in Africa, 3.1% in Oceania, 1.6% in the Americas and 0.5% in Europe), but developing countries account for over 95% of its production (FAO, 2011). Over 75% of the chickpea production comes from South Asia, where India is the largest chickpea producing country accounting for 67% of the global chickpea production. The other major chickpea producing countries include Pakistan, Turkey, Australia, Myanmar, Ethiopia, Iran, Mexico and Canada. During the triennium 2007-2009, the global chickpea area was about 11.3 million ha with a production of 9.6 million MT and average yield of approximately 849 kg per ha.

Chickpea is an important source of protein for millions of people in the developing countries, particularly in South Asia, who are largely vegetarian either by choice or because of economic reasons. In addition to having high protein content (20-22%), chickpea is rich in fiber, minerals (phosphorus, calcium, magnesium, iron and zinc) and β-carotene. Its lipid fraction is high in unsaturated fatty acids. There are two types of chickpea – desi (dark-colored seed coat) and kabuli (white- or cream-colored seed coat). Chickpea is used in various ways, such as raw in salads, cooked in stews (from split seeds called "dal" in SA), ground into flour called "besan", fried or roasted for snacks, and eaten as a paste such as hummus in the Middle East. Splits and flours are invariably made from desi type. Chickpea haulms are used for animal feed and are more nutritious than cereal fodder.

Chickpea plays a significant role in improving soil fertility by fixing the atmospheric nitrogen. Chickpea meets 80% of its nitrogen (N) requirement from symbiotic nitrogen fixation and can fix up to 140 kg N per ha from air. It leaves substantial amount of residual N for subsequent crops and adds plenty of organic matter to maintain and improve soil health and fertility. Because of its deep tap root system, chickpea can avoid drought conditions by extracting water from deeper layers in the soil profile.

Increasing preference for vegetable protein and interest in consumption of chickpea has increased its global demand. Chickpea is imported by over 130 countries. Awareness of benefits of chickpea in crop diversification and sustainable agriculture has increased interest of farmers in growing the crop. Chickpea contributes to over 40% of India's total pulse production and is the most important pulse crop of the country. Despite being the largest global producer of chickpea, India needs to import chickpea to meet domestic demand which is higher than the domestic production. On an average, India spent about Rs 440 crores (US$ 97.5 millions) per year on chickpea imports during 2005 to 2008 (FAO, 2011).

During the past four decades, there has been a major shift in chickpea area from the cooler, long-season environments in northern India to warmer, short-season environments in southern India. This is mainly due to expansion of irrigated agriculture in northern India leading to replacement of chickpea with wheat and other cash crops. During 1964-65 to 2008-09, the chickpea area in northern India (Punjab, Haryana, Uttar Pradesh and Bihar states) declined by 4.4 million ha (from 5.14 to 0.73 million ha), while increased in central and southern India (Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka) by 3.5 million ha (from 2.05 to 5.56 million ha). This major shift in chickpea area has implications on chickpea breeding objectives in India.

Drought and heat stresses at reproductive stage are the major abiotic stresses, while *Fusarium* wilt, *Helicoverpa* pod borer, *Ascochyta* blight and dry root rot are the major biotic stresses to chickpea production in both South Asia and Eastern and Southern Africa (ESA).

Though a wide range of improved chickpea varieties are now available, many farmers still continue to grow old varieties and landraces. The farmers are either not aware of improved varieties or do not have access to seed of improved varieties. Thus, the achievements of chickpea improvement research have not fully translated into increased productivity at the farm level. The productivity of chickpea can be substantially enhanced by adoption of improved varieties and associated improved production technologies. There is also scope for enhancing area in the countries of ESA.

Intended targets to be achieved and major activities

The project aims to increase productivity and production of chickpea and the income of poor farmers in target regions by 20%, with improved varieties occupying 30% of the total area by the end of the project year (2017).

The major activities in different objectives are as follows:

Objective 1:

- Development of standardized baseline and market survey instruments and methods;
- Baseline and market survey data collection;
- Compilation and analysis of secondary data for regional situation and outlook reports;
- Development of standardized survey form on end-users preferences for breeders to use in PVS implementation in crop objectives;
- Early adoption studies; and
- Coordination and capacity building for NARS partners including regional partners' workshops and training.

Objective 5

- Identify and enhance adoption of farme- and market-preferred chickpea varieties in water-limited areas;
- Develop improved chickpea germplasm with enhanced tolerance to drought, resistance to *Fusarium* wilt and market-preferred seed traits;
- Enhance capacity of NARS in chickpea improvement research and development and provide training to farmers in improved chickpea production technology.

Objective 8.5

- Improving the availability of Foundation Seed by NARS and other public sector as well as private sector;
- Designing and testing alternative seed production arrangements (tailored to various clients);

- Designing, testing and implementing diffusion, marketing and institutional arrangements to enhance seed delivery (tailored to various client needs);
- Enhancing local capacity to produce, deliver, store and market seed; and
- Enhancing local-level awareness of released varieties (demand creation).

Locations and partners

The target locations selected for chickpea activities in India included two districts (Kurnool and Prakasam) of Andhra Pradesh and two districts (Dharwad and Gulbarga districts) of Karnataka states in southern India. All activities were carried out in partnership with NARES in target locations. The following were the key project partners:

- ICRISAT, Patancheru, Andhra Pradesh;
- Acharya NG Ranga Agricultural University (ANGRAU), Hyderabad, Andhra Pradesh;
- University of Agricultural Sciences, Dharwad (UAS-D), Karnataka;
- University of Agricultural Sciences, Raichur (UAS-R), Karnataka;
- National Seed Corporation (NSC);
- State Farms Corporation of India Limited (SFCI);
- Andhra Pradesh State Seed Development Corporation (APSSDC); and
- Karnataka State Seed Corporation (KSSC).

The following key scientists were involved in project activities from the partner institutes:

ICRISAT

Objective 1	MCS Bantilan, P Parthasarathy Rao, GD Nageswara Rao and R Padmaja
Objective 5 and 8.5	Pooran Gaur, CLL Gowda, ShaileshTripathi(up to April 2010), Arvaind Jukanti (from May 2010) Suresh Pande, HC Sharma, Vincent Vadez, L Krishnamurthy, GV Ranga Rao, and Rajeev Varshney

NARS Partners

State	Objective	Districts/ Townships	Scientists
Andhra Pradesh (AP)	Objective 1	Kurnool & Prakasam	Dr. K Suhasini (ANGRAU, Hyderabad),
	Objective 5 and 8.5	Kurnool	V Jayalakshmi (RARS-Nandyal, Kurnool), A Trivikrama Reddy (RARS-Nandyal, Kurnool) & P Muniratnam (RARS-Nandyal, Kurnool)
		Prakasam	Y Satish (ARS-Darsi) & Y Koteshwar Rao (RARS-Lam)
Karnataka (KA)	Objective 1	Gulbarga & Dharwad	Dr. G N Kulkarni (UAS, Dharwad), Dr. V R Kiresur (UAS, Dharwad)
	Objective 5 and 8.5	Gulbarga	DM Mannur (ARS-Gulbarga)
		Dharwad	PM Salimath (UAS-Dharwad)

RARS=Regional Agricultural Research Station; ARS=Agricultural Research Station; UAS=University of Agricultural Sciences

Socio-Economics/Targeting

Situation and outlook

A number of biotic and abiotic factors limit realization of yield potential, besides the lack of availability of improved seed to farmers. The slow growth of chickpea yield in India can be attributed to: (i) the shift in crop area from favorable to marginal environments; (ii) the slow uptake of improved varieties and other production technologies; and (iii) its cultivation on poor soils under erratic rainfall conditions.

Trade in chickpea is relatively robust and has been growing over time. Close to 10% of the total chickpea produced in 2003-05 entered the international market. Trade statistics indicate a demand-supply imbalance for pulses in Asia. While the quantum of chickpea exports from Asia doubled between 1981 and 2007, overall the region remains a net importer. The increased import demand has induced countries such as Australia and Canada that traditionally did not grow chickpea to emerge as significant exporters now.

Demand and supply projections of chickpea under the business-as-usual scenario for India and Asia corroborate the fact that in the near future, domestic production is unlikely to catch up with growing demand. If current trends in per capita income and production were to continue, by 2020 India's demand for chickpea would increase to 10 million MT worsening India's net trade situation.

The scope of raising chickpea production in Asia through area expansion alone is extremely limited. Therefore the main challenges for research and development are to bridge the gap between actual and attainable yield by enhancing farmers' access to good quality inputs, improved technologies and information; improve the competitiveness of pulse crops through domestic incentives related to production, marketing, processing prices in line with cereals and competing crops; and achieve a technological breakthrough that not only overcomes yield barriers but also provides effective protection against insect pests and diseases, and tolerance to moisture stress.

Baseline survey and adoption studies

Socio-economic and demographic composition of the farmers

The summary details of selected districts for both control and treatment villages for baseline survey are presented in Table 7-1.

Table 7-1: Survey districts and villages for Andhra Pradesh and Karnataka

State	District	Treatment village	Control village
Andhra Pradesh	Kurnool	Pulimaddi (30)*	Brahamanapalli (15)
		Mitnala (30)	Munagala (15)
		Balapanoor (30)	Rasulpet (15)
	Prakasam	Chirakurapadu (30)	Payidipadu (15)
		Kollavaripalem (30)	Bodavada (15)
		Chirvanauppalapadu (30)	Maddirala (15)
Karnataka	Dharwad	Harobelawadi (30)	Kabbenur (15)
		Shirkol (30)	Hansi (15)
		Kumaragoppa (30)	Yemnur (15)
	Gulbarga	Kurikota (30)	Bhushangi (15)
		Farhatabad (30)	Honnakirangi (15)
		Gotur (30)	Bennur (15)

**Figures in parenthesis indicate number of farmers selected in that village*

Andhra Pradesh

The overall sample size was 270 households that included both treatment and control villages. In the adopted villages of Kurnool 40% of the sample farmers were large farmers and 23.3% marginal farmers. In the control villages of Kurnool also 33.3% of the sample farmers were large and 31.33% belonged to medium category. The sampling technique is an appropriate fit as it is confirmed by the post classification of data. In the adopted villages of Prakasam 33.3% of farmers were marginal farmers, 17.8% were small farmers, 24.4% were medium farmers and 24.4% were large farmers. In the control villages of Prakasam 28.9% of the sample farmers were large farmers and 26.7% were medium farmers (Table 7-2).

Table 7-2: Distribution of sample farmers in the study area of Andhra Pradesh

Farm size	Kurnool				Prakasam				Overall			
	A	%	C	%	A	%	C	%	A	%	C	%
Marginal	21	23.3	7	15.6	30	33.3	9	20.0	51	28.3	16	17.8
Small	16	17.8	9	20.0	16	17.8	11	24.4	32	17.8	20	22.2
Medium	17	18.9	14	31.1	22	24.4	12	26.7	39	21.7	26	28.9
Large	36	40.0	15	33.3	22	24.4	13	28.9	58	32.2	28	31.1
Total	90	100.0	45	100.0	90	100.0	45	100	180	100.0	90	100.0

A=Adopted; C= Control

In Kurnool 92.1% of the sample farmers of the adopted villages and 97.7% of control villages reported agriculture as their main occupation. Only 6.6% of the farmers of adopted village and 2.2% of farmers of control village had service/employment as main occupation. In Prakasam district, 98.8% of the sample farmers of the adopted villages and 95.6% of control villages had agriculture as their main occupation. Only 1.1% of the sample farmers of adopted village and 4.4% of farmers of control village had taken service/employment as main occupation. But members of families were engaged in other occupations which yielded some income to the farm household along with the main occupation. Even though income from agriculture is low it is regarded as the main occupation in both districts.

In the adopted villages of Kurnool average operational land holding was maximum for large farmers at 9.0 ha, followed by medium 6.3 ha, and marginal farmers 4.5 ha. In control villages of Kurnool total operational area is maximum for marginal farmers by 8.1 ha followed by large farmers 6.8 ha and small farmers 4.1 ha.

In the adopted villages of Prakasam maximum operational land 4.6 ha cultivated by small farmers, 3.9 ha cultivated by medium farmers and 3.6 ha by large farmers. On contrary control villages total operated land is maximum for large farmers by 5.0 ha, followed by medium farmers 3.0 ha and small farmers 5.7 ha. In both districts the leasing in land is a common practice which changed the operational land of farmers.

Karnataka

Two of the major chickpea growing districts, namely, Gulbarga and Dharwad districts, were selected for the study. In all, 270 farmers spread across two districts, and 12 villages were chosen based on stratified random sampling technique. Of the 12 villages, six were adopted by ICRISAT under the project for transfer of technologies in the next 3-5 years. Six villages which were nearby the adopted villages (with almost similar agro-ecological situations) served as control villages. The district-wise selection comprised 90 farmers from adopted area and 45 from control area in each district. While the sample distribution according to different farm sizes in the adopted area was 22.2% under marginal, 30.5% under small, 27.2% under medium and 20.0% under large farm size. The corresponding values for the control area were 17.7%, 34.4%, 31.1% and 16.7%, respectively (Table7- 3).

Table 7-3: Distribution of sample households in the study area of Karnataka

Farm size	Dharwad				Gulbarga				Overall			
	A	%	C	%	A	%	C	%	A	%	C	%
Marginal	15	16.7	6	13.3	25	27.8	10	22.2	40	22.2	16	17.8
Small	31	34.4	16	35.6	24	26.7	15	33.3	55	30.6	31	34.4
Medium	24	26.7	14	31.1	25	27.8	14	31.1	49	27.2	28	31.1
Large	20	22.2	9	20.0	16	17.8	6	13.3	36	20.0	15	16.7
Total	90	100.0	45	100.0	90	100.0	45	100.0	180	100.0	90	100.0

A=Adopted; C= Control

Agriculture was the main occupation for large proportion of the farmers (over 93.0%) in the adopted and control areas, followed by service/employment (4 to 5 %). Similar trend was observed separately for each district and for adopted and control areas. The main occupation pattern across different farm sizes showed that agriculture was the main occupation for majority of the farmers in each farm size class.

The results showed that a large proportion of the operated land was dry land and was cultivated under rainfed condition by the farmers in both the adopted (96%) and control (92%) areas in Gulbarga district whereas though a similar situation existed in Dharwad district, the difference between adopted (70%) and control (31%) villages was much higher. The remaining proportion of operational land was cultivated under irrigated condition. The average holding size for the adopted farmers varied between 1.4 and 1.8 ha and that for control farmers between 1.2 and 1.8 ha.

Cropping pattern

Andhra Pradesh

Major crops grown in Kurnool are paddy, sorghum, pearl millet, minor millet, pigeonpea, groundnut, sunflower, cotton, tobacco, chillies and chickpea as per the secondary data during 1995. Later the crops, which picked up in terms of area were chickpea, paddy, sunflower, tobacco and chillies sacrificing the area under other crops predominantly grown. While growth in other crops like paddy, tobacco and chillies ranged from 5 to 25%, chickpea growth was more than 150% compared to 1995 indicating clear-cut preference of the farmers to chickpea replacing other crops. Crops replaced were pearl millet, sorghum, minor millet, pigeonpea, and groundnut initially and cotton, tobacco, sunflower and chillies during the recent past.

Chickpea is a major post-rainy season (*rabi*) crop followed by sunflower. Very small area under crops like tobacco, paddy and groundnut was recorded. No area under pigeonpea, cotton, pearl millet and minor millet was reported indicating a total shift in the cropping pattern. Kurnool is one of the seed production centres in Andhra Pradesh for cotton and sunflower crops and despite of this chickpea emerged as best suited crop to the farming situation. In 2007-08 production year chickpea was found to be a priority crop in terms of area allocation. Adopted area sample farmers allocated 327.9 ha of land while control farmers allocated 91.3 ha of land for chickpea. Following chickpea sunflower, sorghum, tobacco, paddy and groundnut share land allocation in that order. The crop production in Kurnool is mainly rainfed and the only exception is paddy, which is grown under irrigation. Sole cropping is a common practice and no intercropping reported both from adopted and control sample farmers.

While in all other crop types the same varieties are grown by adopted area and control sample farmers, which was not true in case of chickpea. Adopted area sample farmers are growing three varieties of chickpea while control area sample farmers are grown two varieties. The improved varieties of chickpea have shown better performance in term of productivity and return per ha.

Prakasam district: Crops grown in Prakasam district a decade ago were paddy, pigeonpea, sorghum, pearl millet, chillies, groundnut, sunflower, cotton, and tobacco and with a negligible area of chickpea (less than 5,000 ha). In recent years, many of the crops like groundnut, cotton, sorghum, pearl millet to a large extent have been replaced by chickpea. In fact, chickpea is competing with crops like tobacco, and chillies, which is evident by the fluctuating area under these crops shown by secondary data at district level during the latter part of the last decade.

The cropping pattern indicated by the present survey conducted in the sample villages of adopted and control Prakasam district is summarized as follows. About 90% of the area surveyed has been occupied by chickpea during post-rainy season and followed by tobacco with traces of area under sunflower. Paddy remained as a main crop during rainy season in the villages with irrigation water. Four types of crop varieties are grown by both adopted and controlled area sample farmers. However, area allocated for chickpea in adopted sample villages are more than twice of controlled villages.

Karnataka

Across the selected districts and area (adopted and control), the gross cropped area was to the tune of 1,207 ha and the net sown area was 805 ha. The cropping intensity was worked out to be 150%. Rainy season crops shared nearly 55% of the gross cropped area while the remaining 45% was planted to post-rainy season crops. The major crops grown during rainy season were pigeonpea, maize, mungbean, sorghum, onion and sunflower, accounting for 13.6%, 11.1%, 10.4%, 6.0%, 5.9% and 2.5% of the gross cropped area, respectively. Duringpost-rainy season, since all the respondents were chickpea growers by choice, the area under chickpea was the highest (36.3%) followed by wheat (5.5%) and sorghum (2.1%).

The cropping pattern was slightly different between districts. In Dharwad, rainy-season and post-rainy season crops shared 52% and 48% of the gross cropped area respectively. The major crops grown during rainy season were maize (18.9%), mungbean (12.8%), onion (9.9%), sorghum (5.4%), sunflower (2.1%) and cotton (2.0%), while in post-rainy season, chickpea (34.9%), wheat (9.2%) and sorghum (2.7%) were predominantly cultivated. This pattern was almost similar in adopted and control villages of Dharwad district, with a lone exception of mungbean being less predominant than onion.

In Gulbarga district, 58% of the gross cropped area was occupied by rainy season crops as against 42% in post-rainy season crops. The major rainy season crops were pigeonpea, (occupying 32.8% of the gross cropped area), mungbean (7.0%), sorghum (6.9%), sunflower (3.2%) and urdbean (2.6%), whereas chickpea (38.2%) and sorghum (1.2%) were the important post-rainy seasoncrops. Thus, Gulbarga district has been called the “Pulse bowl of India”.

Reasons for growing chickpea

Andhra Pradesh

Ranks for reasons for growing chickpea crop were captured and Garrett scores were worked out. Chickpea is preferred by Kurnool (adopted) village farmers because of fodder availability for livestock (76), fetching higher income (54.8), low risk and less labor requirement (52.11) for farm operations, but the control villages farmers adopted chickpea due to low risk and less labor intensive nature of the crop (54.38) and higher income (52.17). In Prakasam district, farmers of adopted and control villages also indicated that they preferred chickpea as it is a low risk (57.14) and higher income generating crop (55.82).

Karnataka

The most important reasons for growing chickpea by the sample respondents were ascertained and analyzed using Garrett Scores. Across districts and areas, the most important reason for growing chickpea was higher income as indicated by the highest Garrett Score (63.54), followed by restoration of soil fertility (32.12), food/home consumption (22.06) and fits well into the present cropping system (16.58). Similar pattern existed in adopted and control areas separately and also in Dharwad district individually. However, in Gulbarga district, low cost of cultivation was more important than fitting well into the cropping system.

Adoption of improved chickpea varieties

Andhra Pradesh

A 4-decade old desi variety Annigeri was earlier the ruling variety in entire Andhra Pradesh, including Kurnool and Prakasam districts. Even though there is late entry of chickpea in Prakasam district, farmers were interested to try new varieties, and this is why they have now almost abandoned the old variety Annigeri. Meanwhile, Kurnool farmers have also started replacing Annigeri with JG 11. The areas under chickpea varieties JG 11 and Annigeri in Kurnool district was about 52% and 46%, respectively. On the other hand Kabuli, JG 11 and Annigeri in that order occupied 49%, 48% and 3% of the area in Prakasam. Large-seeded kabuli varieties are picking up in Prakasam due to market preference. During the early adoption survey tremendous response was noted for JG 11.

In the early adoption survey an attempt was made to elicit the responses of the farmers regarding their experience with drought and its manifestation and the visualized impact of drought on the chickpea yield. Their opinion on various components - like rainfall, heavy rains, temperature, distribution of rainfall and quantum of rainfall - related to drought were observed in order to capture impact and nature of drought.

In Prakasam district in the adopted villages, 46.6% farmers agreed that the occurrence of heavy/untimely rains affected the crop, 52.2% farmers expressed that the incidence of pest and diseases is a major source of vulnerability to chickpea cultivation and 1.12% farmers said that the drought conditions were responsible for reduction in yields. The overall data of Prakasam farmers indicated that in adopted villages, 63.34% farmers expressed that the heavy/untimely rains effected crop. In the adopted villages of Kurnool district, 44.4 % and in control villages 48.8 farmers expressed that the monsoon resulted in the poor quality seeds.

Karnataka

The farmers, by and large, continue to grow Annigeri-1 and it is still an important variety cultivated by a large proportion of farmers and on a large area even though the grain size is smaller it has high consumer preference and market demand. However, the farmers are looking for new chickpea variety/varieties of high yielding nature which can substitute Annigeri-1. The other preferred traits are resistance to pod borer, resistance to wilt and drought tolerance in the new varieties. According to them, cooking preparations made out of Annigeri variety are tasty and have better keeping quality (high consumer preference) therefore has high market demand for varied purposes. This variety is relatively drought tolerant and gives some yield (500 to 700 kg per ha) even under adverse moisture stress conditions.

The increasingly popular variety JG 11 was found in both the adopted and control villages. However, due to intervention efforts in the adopted villages, relatively more number of farmers (around 18%-20%) were observed to be cultivating this variety. This variety was found also in the control villages (approximately among 10% to 12%). Lack of information on the new varieties and non-availability of good quality seed are the major constraints in using (borrowing or purchasing) the new varieties. The other variety adopted in the villages was desi chickpea variety BGD-103 and according to farmers this has larger seed than the variety JG 11. However, farmers gave the feedback that protective irrigation in BGD-103 and JG 11 significantly enhance yield. The preference for Kabuli type varieties was not very much observed among the farmers both in adopted and control villages because of market constraints for these varieties. Further, Kabuli varieties with thin seed coat may become susceptible to storage pests. MNK-1 (Kabuli type) has extra-large seed and requires high moisture and favorable production conditions in the production period. According to farmers the important criterion to be taken in evolving new varieties is drought tolerance. As the crop is mainly grown under rainfed condition in post-rainy season and it gets exposed to dry spells and water stress conditions during its pod formation stage, the ability to withstand stress conditions by the variety is important for better yields. In Dharwad district farmers preferred to grow Bhima variety which is used as green peas for table purpose.

Constraints in adoption of chickpea varieties

Andhra Pradesh

The major constraints in the existing varieties as expressed by the farmers were as per the Garrett scores shown that low yield (61.5%), small grain size (52.2%), poor taste (50.2%) and high pest incidence (49.6%) were major problems with Annigeri variety in Kurnool; low yield (65.7%), long duration (61.1%), small grain size (58.1%) and high pest incidence (45%) were major constraints for Annigeri in Prakasam. JG 11variety has constraints like poor taste (57%), low yield (56.2%), poor color (55.2%) and high pest incidence (53.8%) in Kurnool and poor color (69.8%), small grain size (60.7%), poor taste (58%) and low yield (51.8%) in Prakasam. Though Kabuli varieties are grown in negligible area in Kurnool the constraints spelt were low yields (70%), low recovery on shelling (50%) and high disease incidence (50%) and in Prakasam KAK 2 (Kabuli) cultivar has constraints like low yield (68.3%), long duration (55.6%), small grain size (55.3%), high pest incidence (47.9%) and high disease incidence (47.6%). The most important constraints faced by farmers are lack of information on varieties, lack of seed supply, no information on market response, high price fluctuations.

Karnataka

The constraints faced by the chickpea varieties in terms of production, marketing and consumption are analysed using Garrett Ranking Method. The Annigeri, Kabuli and local varieties were cultivated by the farmers in the study districts both in adopted and control areas, except that Bhima variety was also cultivated additionally in Dharwad-Adopted situation. However, Annigeri variety was popularly cultivated by large proportion of farmers both in adopted and control areas of the study districts. In general, across all varieties, areas (adopted and control) and districts, low yield (Garrett Score (GS) =20.93) was the major constraint confronted by the farmers in chickpea production. The major constraints in descending order of priority were high pest incidence (GS=16.24), small grain size (GS=14.01), low market price (GS=12.02), low recovery/shelling percentage (GS=11.42), high disease incidence (GS=10.73) and long crop duration (GS=9.83).

Coming to variety-wise constraints, cultivators of Annigeri variety in Dharwad district faced the constraints of low yield, high pest incidence, low recovery/shelling percentage and high disease incidence, both in adopted and control areas, but with varying order. However, in Gulbarga, though low yield and high pest incidence topped the list in both adopted and control villages, the other constraints of severity were small grain size and low market price. One of the reasons for low market price was small grain size.

In the case of Kabuli variety, while low yield, high pest incidence, high disease incidence and long duration were the major constraints in Dharwad-adopted area, Dharwad-control area was confronted with high pest incidence, high disease incidence, poor taste and low yield in that order. In Gulbarga, on the other hand, adopted area was confronted with the constraints of low yield, small grain size and high disease incidence whereas low yield, long duration, small grain size and poor taste were the major constraints faced by their counterparts in control area. For Bhima, which was cultivated only in Dharwad-adopted area, the serious bottlenecks were high disease incidence, low recovery/shelling percentage, small grain size, low yield, high pest incidence and low market price. If nothing can be done by the researchers about low recovery/shelling percentage, grain size and low market price, at least pests and diseases could be controlled through improved agronomic practices which would probably enhance its yield and promote its adoption in Gulbarga district and other areas of Dharwad district.The constraints faced by the farmers in cultivating local varieties of chickpea varied between districts and areas (adopted and control).

Preferred traits in chickpea varieties

Andhra Pradesh

In Kurnool district of Andhra Pradesh, Annigeri variety is preferred with high yield (63.44%), drought resistance (48.9%), short duration (45.73%) and pest resistance (41.32%). Prakasam farmers also preferred high yield (68.71%), short duration (58.59%), drought resistance (54.7%) and pest resistance (40.89%) for Annigeri. Clarifying their trait preferences for specific varieties: for JG -11 variety in Kurnool district, short duration (70.75%) was the first preferred trait, high yield (61.2%) and drought resistance (51.86%) were the next preferences. Kurnool farmers also responded for KAK 2 variety that high yield, (70%) and disease resistance (50%) were first and second preferences. In Prakasam district, the traits preferred (which characterized JG 11 variety) were high yield (67.5%), short duration (62.8%), drought resistance (51.1%) and pest resistance(39.2%). Similarly KAK 2 variety was preferred with traits such as high yield (66.97%), short duration (59%), drought resistance (49.35%) and pest resistance (43.23%) by the Prakasam district farmers.

Karnataka

High yielding performance (93%) was the most single preferred trait across all study situations (district-area-variety combinations), with the lone exception of Bhima in Dharwad-adopted village situation, where pest resistance was preferred to high yield. Aside from pest resistance, the other traits mentioned as desirable were drought resistance, improvement in soil fertility, disease resistance, short duration, fitting into cropping system and more recovery/shelling percentage, in that order, across varieties and locations. Among the consumption traits, better taste, high keeping quality and less cooking time were the most preferred ones, in that ranked order, across varieties and locations. The preference for fodder traits elicited from the farmers indicated that more fodder quantity, more durability of fodder and palatability (quality/taste) were ranked in order of priority across locations and varieties.

Gender roles in chickpea cultivation

Andhra Pradesh

It has been observed that men perform activities like land preparation, field cleaning, chemical fertilization, mechanical weeding and plant protection measures. The activities performed mainly by women are field cleaning 6.67% and 7.78%, hand weeding 43% and 54%, harvesting 7.78% and 23.33% in Kurnool and Prakasam districts, respectively. Major activities performed by both men and women together are sowing the seed, field cleaning, fertilizer application, fodder harvesting and intercultural operations. The harvesting of main crop is done by both men and women together as per 67% to 68% of the respondents' opinion. Threshing is also done by both men and women jointly.

Karnataka

The major activities performed by men in the adopted and control areas of both the districts were selection of crop and variety (85.56% each), followed by transport of grain and land preparation (more than 70% each), storage of produce (67.78%), plant protection measures (65.19%) and assistance in the field cleaning operations (58.52%). The role of women was very conspicuous in hand weeding as expressed by nearly 18.15% of them in both the districts, followed by fodder harvesting and seed treatment in Dharwad district and only seed treatment in Gulbarga district. However, men had a meager role (25% to 33%) in the activities like seed selection, storage and its treatment, watch and ward, harvesting of fodder and main crop, stacking fodder and hand weeding. It was observed that a majority of the farm related activities were performed by men and women jointly. Harvesting of main crop was done jointly as expressed by a majority of the farmers (70.74%), followed by hand weeding (66.30%), harvesting of fodder (61.11%), sowing of seed (55.19%, intercultural /mechanical weeding (55.19%), threshing (52.96%) and application of chemical fertilizer (52.22%).

Cost-benefit analysis for chickpea cultivation

Andhra Pradesh

The benefit cost ratios ranged from 1.22 to 1.33 in Kurnool and Prakasam districts. Net returns from the production of chickpea are Rs 4201 per ha in Kurnool district while the net returns are much lower in case of Prakasam district. The crop provided about 40 days of employment for men and 25 days of women labor employment. The overall labor required is distributed in the ratio of 2:3 and 1:3 among the men and women labor employed. If proper knowledge about the significance and costs efficiency in each operation is not known to women it may result in low yield of crop.

Karnataka

The overall results for all chickpea varieties together on one hand and separately for each variety on the other cultivated in the study area was found to be economically viable. This was indicated by benefit-cost ratio (BCR) of more than one (> 1) and positive net returns on chickpea crop. The overall net returns over fixed cost were positive and was Rs. 7260/ha in adopted villages and B:C ratio was 1.50. Similar observation was made for different chickpea varieties. Net returns over fixed cost in case of Annigeri for adopted villages was Rs.7191/ha. and the corresponding B:C ratio is1.49. In case of Kabuli varieties, corresponding net returns and B:C ratios were Rs.8261/ha (BCR-1.55). Bhima and local varieties also followed a similar trend in respect of net returns and BCR. Among various costs incurred human and bullock labor accounted a substantial proportion in the total cost.

Drought research issues

Andhra Pradesh

The two areas under study have twin problem of drought and flood, Prakasam being coastal district was effected by floods during 2007-08 and Kurnool was affected by floods during 2009-10 (First week of October due to back waters of reservoirs nearby and heavy rains received in and around Kurnool within a span of 48 hours indicating the warning signals of climate change in dry and low rainfall areas during post-rainy season). Drought is a regular feature in these two districts hence diversification in the income earning are important. There was diversification in income earning activities of different family members even though Agriculture is treated as main activity. Detailed studies are needed to assess potential impacts of climate change on agriculture production in drought affected areas.

Karnataka

Delayed monsoons in recent years often cause drought conditions in Dharwad district. While, Gulbarga is one of the chronically drought hit districts of the state and frequent droughts are very common making farmers' livelihood more difficult. Thus, the research priorities in the wake of recurring drought conditions and also due to market driven preferences should mainly be focused. Need to develop suitable varieties by strengthening crop improvement program to overcome uncertainties in yield and income of the farmers in the area. Need to strengthen the seed supply chains (institutional linkages among R&D organizations, private seed companies, NGOs, KVKs, local village institutions) for production and distribution of quality seed to farmers. Popularize new varieties on mission mode through approaches like, training, demonstrations, trials, field days, farmers' fairs, etc.

Fast-Tracking, Development, and Release of Varieties

Development of varieties

The current status of adoption of improved varieties and traits preferred by the farmers were assessed during a regional work planning meeting organized at ICRISAT-Patancheru at the beginning of the project. Considering the requirements of target regions, the chickpea improvement program was focused on developing breeding lines with high yield potential and market-preferred seed traits, early maturity, drought tolerance and resistance to fusarium wilt and pod borer.

A large number of promising breeding lines were selected at ICRISAT-Patancheru and supplied to project partners. Two international chickpea screening nurseries (ICSNs), one for desi type (ICSN-Desi) and one for kabuli type (ICSN-Kabuli) were constituted each year and supplied to project partners during 2007/08, 2008/09, 2009/10 and 2010/11. Each ICSN consisted of 18 advanced breeding lines, one common check and one local check. The partners identified promising breeding lines from these nurseries for further evaluation in station and multilocation trials. The promising lines identified included ICCV 09106, ICCV 09107, ICCV 09112, ICCV 09116, ICCV 09118, ICCV 07103, ICCV 07104 and ICCV 07110 in desi type (>20% higher yield than the check JG 11/ICCC 37) and ICCV 06302 in kabuli type (>10% higher yield than the check KAK 2). Considering the demand of extra-large seeded kabuli chickpeas, one additional ICSN, ICSN-Kabuli large seed, was constituted and supplied to partners for evaluation during 2010-11. Several lines (ICCV 10411, ICCV 10410, ICCV 10402 and ICCV 10404) with larger seed than the check ICCV 95334 were identified.

In addition to ICSNs, a set of 137 advanced breeding lines (81 desi, 56 kabuli) was also supplied to project partners. These were evaluated in replicated yield trials along with 3 checks at 4 locations in India (Patancheru, Nandyal, Dharwad and Gulbarga) in randomized block design with two replications during 2009/10. Several high yielding lines were identified compared to common checks at different locations. The best performing desi lines compared to respective checks were D064 (71.0%) at Patancheru, D019 (33.0%) at Nandyal, D051 (19.0%) at Dharwad and D005 (25.0%) at Gulbarga. Among top 10 desi lines, D043 genotype showed good performance over three locations (Patancheru, Nandyal and Gulbarga. The promising kabuli breeding lines that outperformed the common check included ICCV 08307 (33.0%) at Patancheru, ICCV 08313 (72.0%) at Nandyal, and K010 (91.0%) at Gulbarga. None of the Kabuli lines performed better than the common checks at Dharwad. The project partners will further evaluate selected lines in station trials along with other selected lines.

The chickpea breeding activities of TL-I and TL-II projects are well integrated. TL-I is using marker-assisted breeding for improving precision and efficiency of chickpea breeding. A genomic region controlling several traits related to drought tolerance (root length density, root biomass, shoot biomass, harvest index) has been introgressed in three farmer-preferred varieties (JG 11 and KAK 2 from India and Chefe from Ethiopia) using marker-assisted backcrossing breeding approach. The BC3F4 progenies have been distributed to TL-II partners for evaluation. In another activity of TL-I, marker-assisted recurrent selection (MARS) is being used to accumulate favorable alleles for yield under moisture stress conditions.The progenies developed from MARS will also be shared with TL-II partners.

Pod borer (*Helicoverpa armigera*) is the most devastating insect-pest of chickpea and the levels of resistance available in the cultivated chickpea are very low. Some accessions of wild species have been reported to have higher levels of resistance than the best known source of resistance (ICC 506EB) in the cultivated chickpea. Interspecific crosses of *C. arietinum* (cultivated chickpea) x *C. reticulatum* (wild progenitor of chickpea) are being used to enhance resistance to pod borer.Forty F_6 progenies derived from the cross between *Helicoverpa*-resistant *C. arietinum* accession ICC 506EB and the *C. reticulatum* accession IG 72953, along with parents and the susceptible checks (ICC 3137 and ICCC 37) were evaluated for resistance to pod borer using detached leaf assay in the laboratory and under no-choice cage conditions in the greenhouse. Some interspecific progenies with better levels of resistance (based on leaf feeding scores, weight gain by the neonate larvae, larval survival and pod damage) than either of the parents involved in the crosses were identified for further evaluation.

Identification of farmer-and-market preferred varieties

The current status of adoption of improved varieties and traits preferred by the farmers were assessed during a regional work planning meeting organized at ICRISAT-Patancheru at the beginning of the project. Taking into account farmer and market preferred traits, eight improved varieties/breeding lines (4 desi + 4 kabuli) were selected for PVS trials (Table 7-4) at each of the four project locations (Kurnool and Prakasam districts in Andhra Pradesh and Dharwad and Gulbarga districts in Karnataka). Twenty mother trials and 217 baby trials were conducted in 23 villages (5 to 8 villages in each district) during 2007-08 to expose farmers to improved varieties and allow them to select varieties of their preference. The crop in Prakasam district of Andhra Pradesh was destroyed in the first year by heavy rains at maturity, so PVS trials were repeated in the second year (2008-09). A total of 1,181 farmers (1,052 men + 129 women) were involved in ranking of varieties in PVS trials. The desi chickpea varieties JG 11 and JAKI 9218 were preferred in all four districts. In addition to these, desi chickpea cultivar JG 130 was preferred in both the districts of Andhra Pradesh, while desi chickpea cultivar BGD 103 and kabuli variety MNK 1 was preferred in both the districts of Karnataka. Farmers in Prakasam district of Andhra Pradesh also preferred kabuli chickpea cultivar KAK 2. The traits for which these varieties were preferred included, profuse podding, high productivity, early maturity, resistance to fusarium wilt, and market-preferred seed traits (e.g. medium seed size in desi type and large seed size in kabuli type).

Table 7-4: Varieties used in PVS trials and varieties preferred by the farmers

State	Varieties used in PVS trials	Varieties preferred by farmers
Andhra Pradesh	*Desi:* ICCC 37, JG 11, JG 130, JAKI 9218, Annigeri (local check) *Kabuli:* Vihar, LBeG7, JGK 2, ICCV 95334, KAK 2	*Desi:* JG 11, JAKI 9218, JG 130, *Kabuli:* KAK 2 (in Prakasam district)
Karnataka	Desi: BGD 103, JG 11, JG 130, JAKI 9218, Annigeri (local check) *Kabuli:*Vihar, BG 1105, MNK 1, ICCV 95334, KAK 2	*Desi:*JG 11, JAKI 9218, BGD 103, *Kabuli:* MNK 1

Varieties release

All varieties included in the PVS trials were released varieties, except BGD 102 (desi) and MNK 1 (kabuli) which were elite lines at pre-release stage. The results of PVS trials strengthened release proposals of these varieties. The variety BGD 103 was released and notified for cultivation in Karnataka state of India during 2009. This is a large-seeded variety with early maturity (escapes terminal drought), high resistance to fusarium wilt and high yield potential. The variety MNK 1 is a large seeded (52 g/100-seed) kabuli variety. It was released by the Central Variety Release Committee for South Zone of India, which includes Karnataka, Andhra Pradesh, Tamil Nadu and Orissa.

Seed Production and Delivery Systems

The Objective 8.5 (Seed Systems for SA) aims at improving seed production and delivery system for legumes. The economics of legumes seed production is not attractive enough for organized private seed sector due to their large seed size resulting in high volume and consequently high costs in transportation and storage. On the other hand, public seed sector is not able to produce the required quantities of seed. Although many state governments arrange to supply seed to farmers at a subsidized cost (often this subsidized seed is not delivered to farmers in time), the quantity made available is limited and the quality and varietal integrity is often questionable. Therefore, farmers have to often reach local traders (who care little for varietal integrity and quality) and co-farmers for their seed requirement.

This project established efficient linkages for the efficient seed production and marketing of legumes in the project sites. The Seed Systems objective (Objective 8) was instrumental in catalyzing the scaling up of Foundation and Certified seeds, seed delivery testing models, and raising farmer awareness.

Breeder seed and other classes of seed produced by research partners

Excellent progress was made in chickpea seed production and distribution by the project partners in the target states (Andhra Pradesh and Karnataka). The research partners were mainly engaged in production of Breeder seed (BS), but also produced limited quantities of certified seed (CS) and truthfully-labeled seed (TLS). They together produced over 2,000 MT seed, which included 1,207 MT BS, 205 MT CS and 681 MT TLS (Tables7-5 to 7-7). The seed was produced both at the research stations and the farmers' fields under their direct supervision. The share of JG 11 was 84% in BS and 71% in CS and TLS (Table 6&7)

Table 7-5: Seed produced (in MT) by research partners in target regions

State & District	Class of seed	2007-08		2008-09		2009-10		2010-11		Total
		Station	Farmers' fields	Station	Farmers' fields	Station	Farmers' fields	Station	Farmers' fields	
RARS-Nandyal	BS	19.1	-	65.1	-	-	203.0	-	43.0	330.2
	CS	-	60.0	-	-	-	-	-	-	60.0
	TLS		3.8		80.0	0.2	30.9		77.0	191.9
ARS-Darsi	BS	-	-	-	46.1	-	375.4	2.0	-	423.5
	CS	-	-	-	-	-	-	-	-	-
	TLS	-	-				30.0	-	62.7	92.7
UAS-Dharwad	BS	2.5		4.4	4.0	0.4	1.0	65.3	-	77.6
	CS	-	3.2	-	-	-	-	-	42.0	45.2
	TLS	-	-	-	-	-	40.0	-	1.8	41.8
ARS-Gulbarga	BS	4.6	-	2.0	327.8	8.0	-	8.5	-	350.9
	CS	-	-	-	-	-	100.0	-		100.0
	TLS	-	105.0	-	-	-	20.0	-	230.0	355.0
ICRISAT	BS	4.6	-	7.8	-	12.1	-	-	-	24.5
	CS	-	-	-	-	-	-	-	-	-
	TLS	-	-	-	-	-	-	-	-	-
Total	BS	30.8	0.0	79.3	377.9	20.5	579.4	75.8	43.0	1,206.7
	CS	0.0	63.2	0.0	0.0	0.0	100.0	0.0	42.0	205.2
	TLS	0.0	108.8	0.0	80.0	0.2	120.9	0.0	371.5	681.4
Grand Total		30.8	172.0	79.3	457.9	20.7	800.3	75.8	456.5	2,093.2

Table 7-6: Breeder Seed of different varieties produced (MT) by research partners under Tropical Legumes II Project

Variety	2007-08	2008-09	2009-10	2010-11	Total
JG 11	24.7	366.0	545.2	79.2	1,015.1
JAKI 9218	2.8	24.6	10.2	3.0	40.6
JG 130	1.3	1.9	14.5	-	17.7
LBeG 7	0.1	-	-	-	0.1
KAK 2	0.5	3.5	26.3	33.6	63.9
BGD 103	1.2	60.1	3.2	2.0	66.5
Vihar	0.3	-	0.9	-	1.2
MNK 1	0.2	1.2	-	1.0	2.4
JGK 1	-	-	-	-	-
JGK 2	0.2	-	-	-	0.2
ICCV 95334	0.2	-	-	-	0.2
Total	31.4	457.1	600.3	118.8	1,207.6

Table 7-7: Certified and Truthfully Labeled seed of different varieties produced (MT) by research partners under TL II

Variety	2007-08	2008-09	2009-10	2010-11	Total
JG 11	152.7	60.0	142.6	270.2	625.5
JAKI 9218	-	20.0	25.0	48.8	93.8
JG 130	-	-	9.7	19.8	29.5
LBeG 7	3.8	-	-	-	3.8
KAK 2	-	-	8.1	16.6	24.7
Vihar	-	-	0.8	26.3	27.1
BGD 103	12.7	-	35.0	31.8	79.5
MNK 1	2.8	-	-	-	2.8
Total	172.0	80.0	221.1	413.5	886.5

Foundation and Certified Seed produced by public seed corporations

The PVS trials and various awareness activities created demand of seed of farmer-preferred varieties. There was a strong partnership between research partners and Public Seed Corporations, where research partners produced breeder seed and the Public Seed Corporations produced Foundation seed (FS) and CS. The four seed corporations (NSC, SFCI, APSSDC and KSSC) together produced 74,531 MT seed that included 70,607 MT CS and 3,924 MT FS (Tables 8&9). JG 11 was the most popular variety with 85% share in CS (Table 7-9).

Table 7-8: Seed produced (MT) by the public seed sector in target regions

Public seed sectors	Class of seed	2007-08	2008-09	2009-10	2010-11	Total
NSC	Foundation	-	-	-	19	19
	Certified	166	279	1,899	1,700	4,044
SFCI	Foundation	61	107	464	250	882
	Certified	2,658	1,716	1,890	2,850	9,114
APSSDC	Foundation	811	844	619	750	3,023
	Certified	10,399	15,183	12,594	17,500	5,5675
KSSC	Foundation	-	-	-	-	-
	Certified	18	600	825	330	1,773
Total	Foundation	872	950	1,083	1,019	3,924
	Certified	13,241	17,777	17,208	2,2380	70,607
Grand Total		14,113	18,728	18,291	23,399	74,531

Table 7-9: Foundation and Certified seed of different varieties produced by the public seed sector in target regions

Variety	Class of seed	2007-08	2008-09	2009-10	2010-11	Total
JAKI 9218	Foundation	-	42	307	250	598
	Certified	-	-	1,277	2,500	3,777
JG 11	Foundation	872	861	725	570	3,027
	Certified	13,098	17,531	15,049	14,180	59,858
KAK 2	Foundation	-	48	51	199	298
	Certified	143	247	883	5,700	6,973
	Total	14,114	18,728	18,291	23,399	74,531

Seed samples distributed to farmers

Seed samples of different sizes (2, 4, 5, 12, 15 and 20 kg) of farmer-preferred varieties were distributed to farmers for enhancing their awareness about improved varieties and making available initial quantity of high quality seed for further multiplication. Close to 5,000 seed samples were distributed in four target districts (Table 7-10). The total quantity of seed distributed was 47.5 MT.

Table 7-10: Distribution of seed samples to farmers

Varieties	Sample size (kg)	Number of samples				Total samples	Total seed distributed (kg)
		RARS-Nandyal	ARS-Darsi	UAS-Dharwad	ARS-Gulbarga		
JAKI 9218	2		150			150	300
	4	115		75		190	760
	5	150			50	200	1,000
	20		25		20	45	900
JG 11	2				600	600	1,200
	4			200		200	800
	5	100		210	199	509	2,545
	15			40		40	600
	20		25		1,614	1,639	32,780
Vihar	2		50			50	100
	5	20				20	100
BGD 103	2				500	500	1,000
	4			300		300	1,200
	5				118	118	590
	12			30		30	360
	20				98	98	1,960
JG 130	2		150			150	300
	4	115				115	460
KAK 2	20		25			25	500
Total						4,979	47,455

Capacity building

Knowledge empowerment of farmers, extension personnel and seed traders

Training of farmers in chickpea crop and seed production technologies

Training of farmers in improved chickpea production technology, seed production and storage was given high priority. Over 150 training programs were organized by NARS partners in target locations and training was provided to 12000 (10,842 men + 1,158 women) farmers (Table 7-11). The various topics covered in the trainings included PVS trials, improved chickpea varieties, improved chickpea production technologies, integrated pest management; seed production, processing and storage; and post-harvest value addition.

Table 7-11: Training of farmers in improved chickpea crop and seed production technologies

Year	AP-Kurnool		AP-Prakasham		KA-Dharwad		KA-Gulbarga	
	Men	Women	Men	Women	Men	Women	Men	Women
2007-08	174	20	-	-	165	48	167	-
2008-09	572	37	558	69	2,098	127	1,397	208
2009-10	630	28	462	52	1,380	260	1,566	73
2010-11	325	25	446	112	380	12	522	87
Total	1,701	110	1,466	233	4,023	447	3,652	368

Field days and farmers fairs

A total of 48 field days and 10 farmer's fairs (also called Kisanmela or KrishiMela) were organized in which about 27,000 farmers (24,290 men + 2697 women) participated (Table 7-12). These events exposed farmers to improved varieties and production technologies and gave them opportunities of interacting with researchers, extension personnel and developmental agencies.

Table 7-12: Field days and farmers' fairs organized

	Event	AP-Kurnool			AP-Prakasham		
		No. of Events	Men	Women	No. of Events	Men	Women
2007-08	Field day	1	30	-	-	-	-
	Farmers fair	-	-	-	-	-	-
2008-09	Field day	5	225	27	3	280	18
	Farmers fair	1	1,100	100			
2009-10	Field day	6	238	5	3	98	5
	Farmers fair	1	1,300	400	-	-	-
2010-11	Field day	4	155	10	7	279	19
	Farmers fair	2	1,950	138	-	-	-
Total		20	4,998	680	13	657	42
		KA-Dharwad			KA-Gulbarga		
2007-08	Field day	-	-	-	2	200	-
	Farmers fair	1	200	30	-	-	-
2008-09	Field day	3	190	15	-	-	-
	Farmers fair	1	500	100	-	-	-
2009-10	Field day	10	1,405	330	1	180	-
	Farmers fair	-	-	-	1	3,400	800
2010-11	Field day	-	-	-	3	810	-
	Farmers fair	2	10,450	200	1	1,300	500
Total		17	12,745	675	8	5,890	1,300

Awareness creating activities through electronic and print media

Efforts were made to reach large number of farmers through electronic and print media to disseminate information on improved varieties and crop production technologies. The project partners organized 12 radio programs, 21 TV programs including live question and answer sessions, and 21 popular articles in local magazines and newspapers (Table 7-13).

A chickpea seed production manual was published in English, Telugu (for Andhra Pradesh) and Kannada (for Karnataka) languages. The English version is available online (www.icrisat.org/tropicallegumesII/pdfs/ChickpeaManual_full.pdf).

Table 7-13: Farmers awareness activities conducted from September 2007 onwards

	AP-Kurnool			AP-Prakasham		
Season	Radio programs	TV programs	Popular/ Newspaper articles	Radio programs	TV programs	Popular/ Newspaper articles
2007-08	1	1	1	-	-	-
2008-09	3	2	2	2	1	-
2009-10	2	3	2	-	2	-
2010-11	3	1	1	-	1	-
Total	9	7	6	2	4	0
	KA-Dharwad			KA-Gulbarga		
2007-08	-	-	1	-	1	1
2008-09	-	-	1	-	4	6
2009-10	-	2	4	-	1	-
2010-11	1	2	2	-	1	-
Total	1	4	8	0	7	7

Training of extension personnel

The extension personnel of the Department of Agriculture (Agriculture Extension Officers, Assistant Directors of Agriculture) and NGOs were trained as Master Trainers in improved production technologies so that they can effectively impart training to farmers. Eleven training programs were organized in India in which 1411 extension personnel (1229 men + 182women) participated (Table 7-14).

Table 7-14: Training of extension personnel in chickpea crop and seed production

Season	AP-Kurnool		AP-Prakasham		KA-Dharwad		KA-Gulbarga	
	Men	Women	Men	Women	Men	Women	Men	Women
2007-08	70	5	25	5	55	5	100	30
2008-09	115	-	72	12	87	9	30	-
2009-10	86	6	26	3	15	4	153	52
2010-11	224	19	131	22	-	-	40	10
Total	495	30	254	42	157	18	323	92

Training of seed traders

In addition to public seed sector, the local seed traders play important role in making seed available to farmers. This is particularly important when the private seed companies have little involvement in legume seed industry. The local seed traders generally procure seed from farmers and sale to other farmers. Training programs were organized for improving their knowledge and skill of local seed traders in proper handling of seed. A total of 130 seed traders (68 traders in AP and 62 traders in KA) were provided training (Table 7-15) on seed processing and safe storage. It was interesting to note that the local seed trading business was dominated by men.

Table 7-15: Training of local seed traders in proper seed handling from September 2007 onwards

	AP-Kurnool		AP-Prakasham		KA-Dharwad		KA-Gulbarga	
	Men	Women	Men	Women	Men	Women	Men	Women
2007-08	-	-	-	-	-	-	-	-
2008-09	-	-	-	-	15	-	-	-
2009-10	20	-	12	-	12	-	35	-
2010-11	22	-	14	-	-	-	-	-
Total	42	0	26	0	27	0	35	0

Training of scientists and research technicians

Two one-month training courses on "Chickpea Breeding and Seed Production" were organized at ICRISAT-Patancheru. The first course was organized during Jan-Feb 2008 and the second course during Jan-Feb 2009. Twelve researchers (9 men + 3 women) from the NARS of Ethiopia, Tanzania and Kenya participated (Table 16). The topics covered included conventional and biotechnological (genomic and transgenic) approaches of chickpea improvement and improved practices for chickpea cultivation and seed production. The participants also had opportunity to visit other organizations in Hyderabad working on seed-related research, seed production, and seed quality testing.

Table 7-16: List of researchers provided one-month training on "Chickpea Breeding and Seed Production" at ICRISAT-Patancheru

Name of trainee	Gender	Country	Designation and affiliation
Jan-Feb 2008			
Mussa J. Hedo	M	Ethiopia	Assistant Researcher (Breeding), DebreZeit Agricultural Research Center, DebreZeit
Ketema D. Abdi	M	Ethiopia	Assistant Researcher (Breeding), DebreZeit Agricultural Research Center, DebreZeit.
Robert O. Kileo	M	Tanzania	Principal Research Officer (Agriculture), Lake Zone Agricultural Research Institute, Ukiriguru, Mwanza
Everina P. Lukonge	F	Tanzania	Principal Agriculture Research Officer, Agricultural Research and training, Ukiriguru, Mwanza
Paul K. Kimurto	M	Kenya	Dept. of Crops and Soil Sciences, Egerton University, Nairobi
Peter Kaloki	M	Kenya	Technician, ICRISAT-Nairobi
Jan-Feb 2009			
Million EsheteWolde	M	Ethiopia	Chickpea and Lentil Research project Coordinator, DebreZeit Agricultural Research Center, DebreZeit
AbebeAtilawGizaw	M	Ethiopia	Coordinator, Seed multiplication and Dissemination, DebreZeit Agricultural Research Center, DebreZeit
Epifania Elias Temu	F	Tanzania	Principal Agriculture Research Officer, Lake Zone Agricultural Research Institute, Ukiriguru, Mwanza
Stella GamalielChirimi	F	Tanzania	Principal Agricultural Field Officer, Lake Zone Agricultural Research Institute, Ukiriguru, Mwanza
Bernard KibetTowett	M	Kenya	Senior Technician, Dept. of Crops, Hort. and Soil Science, Egerton University, Nairobi.
Wilson M Thagana	M	Kenya	Senior Research Officer, Kenya Agricultural Research Institute, Nairobi

Development of infrastructure facilities

The research stations have the responsibility of producing nucleus seed and breeder seed of the varieties developed by their institutes. Modest support was provided to strengthen infrastructure facilities for seed production, processing and storage at the participating research stations. The following facilities were developed:

RARS-Nandyal: Renovation of existing seed storage structures, motorbike, electronic weighing Balance, digital seed counter, sump motor, and multi-crop thresher.

ARS-Darsi: Seed processing plant (capacity: 2 MT/hr), seed storage stands for the seed store and motorbike.

UAS-Dharwad: Mobile seed processing plant, seed storage bins, seed cabinets, and motorbike.
ARS-Gulbarga: Sprayers, seed storage bins, motorbike, digital camera, and computer.

Degree students

Four students (3 men + 1 woman), one PhD student from India (Tosh Garg), two MSc studentsfrom Kenya (Peter Kaloki and Nancy WathimuNjogu) and one MSc student from Ethiopia (TadesseSafera), were accommodated for conducting their theses research on chickpea (Table 7-17). Except one student from Kenya (Peter Kaloki), all students completed all or part of their research work at ICRISAT-Patancheru. Thesis research of two of these students has some components of the application of molecular markers (linked to TL I). Two students (TadesseSefera and Peter Kaloki) have already been awarded degree, one student (Nancy WathimuNjogu) is writing thesis, and the remaining one student (Tosh Garg) is expected to submit his thesis during 2012.

Table 7-17: Degree students conducting research on chickpea activities under TL-II project

Student	Gender	Degree	University	Subject field
Tadesse Sefera	M	MSc	Haramaya University, Ethiopia	Molecular characterization of Ethiopian chickpea varieties
Peter Kaloki	M	MSc	University of Nairobi, Kenya	Genetic variability for high temperature tolerance in chickpea
Nancy Wathimu Njogu	F	MSc	Egerton University, Kenya	*Helicoverpa* resistance in chickpea
Tosh Garg	M	PhD	Punjab Agricultural University, Ludhiana, Punjab	Molecular mapping of multiple disease resistance in chickpea

Key lessons learned

The key lessons learned are as follows:

- Farmers' awareness of the improved varieties and availability of the seed of improved varieties are the key factors in spread of improved chickpea varieties;
- PVS trials are very effective in enhancing awareness of farmers to improved varieties and in spreading new varieties;
- The farmers need some orientation and close follow ups for their active participation in PVS trials;
- Farmers participation in varietal selection reduces the time required for varietal testing and possible high adoption of tested varieties before or after formal release;

- In addition to yield, maturity duration and resistance to diseases, seed traits preferred by market (seed size, color and shape) were also given high wattage by the farmers in selection of improved chickpea varieties. Thus, market-preferred traits are also important for adoption and up-scaling for chickpea improved varieties;
- The farmers' preference for growing kabuli chickpea varieties largely depended on the price premium received over desi type;
- Lack of proper cleaning, grading and storage facilities hampers seed production by individual farmers; and
- The farmers were very keen to take seed production of improved varieties provided arrangement was made for procurement of seed through national/state seed corporations or other agencies.

Enhancing Chickpea Productivity and Production in Eastern and Southern Africa

NVPRG Rao, Said N Silim, Franklin Simtowe (ICRISAT-Nairobi); Pooran M Gaur, CLL Gowda (ICRISAT-Patancheru); Emmanuel S Monyo (ICRISAT-Malawi); Asnake Fikre, Kebebew Assefa (EIAR-Debre Zeit, Ethiopia); Robert Kileo (LZARDI-Ukiriguru, Tanzania); Wilson M Thagana, Ngari Macharia (KARI-Njoro, Kenya)

Summary

The chickpea research and development activities were conducted in three ESA countries, namely, Ethiopia, Kenya and Tanzania with due involvement of NARS, ICRISAT-Nairobi, progressive farmers, NGOs, and all major stakeholders. The project was implemented in Gimbichu, Minjar-Shenkora, Moretna-Jiru, Dembia and Sodo *weredas* (districts) of Ethiopia; four districts of Tanzania, namely Misungwi, Kwimba, Shinyanga and Kishapu districts of Lake Zone; and the rift valley districts of Bomet and Nakuru in Kenya.

The major success was on fast track release of nine chickpea varieties in the three target countries, viz., Ethiopia (1), Tanzania (4) and Kenya (4). The new releases in Tanzania are a landmark as this is the first official release of chickpea in the country; Kenya had only one variety released in 1986.

Baseline studies indicated that most of the farmers rely on own-saved seed and access to seed of improved varieties is either through informal networks or relief seed. Very limited awareness on improved chickpea varieties existed, due to consistent failure of the public sector to supply good quality source seed, reluctance of the private sector to show interest in seed production, and most often seed is produced in high potential areas or areas with infrastructure for storage and processing, far away from its area of utilization, leading to high transaction costs. To overcome these constraints, investments have been made in Breeder and Foundation seed production, and proceeds from seed sales used to re-capitalize seed revolving funds to support subsequent seed production cycles. Foundation Seed has been marketed to private companies and NGOs for further seed production and dissemination. During the past four years (2007-10) a total of 31.7 MT Breeder Seed and 3,602 MT Foundation and Certified seed of farmer-preferred improved chickpea varieties were produced at research stations and farmers' fields.

A total of 186 farmers participatory varietal selection (PVS) trials by involving 6-11 pre-released/released varieties were involved along with farmer' variety as a check, were conducted in Ethiopia (68), Tanzania (47), and Kenya (71), and 3,087 farmers (Ethiopia 2,611, Tanzania 318, and Kenya 569) participated. In addition, 525 field demonstrations in Ethiopia were organized to disseminate promising varieties and production technologies. During the PVS farmers came up with a number of preferred traits which facilitated short-listing of varieties for fast track release. In total, 25 field days were conducted in target locations of Kenya (11), Tanzania (8) and Ethiopia (6) with the participation of 2,523 farmers (Kenya: 855; Tanzania: 958; and Ethiopia: 710). During the field days farmers were asked to select preferred varieties along with preference criteria. In Kenya, demonstrated the utilization of chickpea products and elicited the feedback on most preferred chick based products and farmers rated *githeri* and stew as the preferred products.

Several training programs were organized to improve the knowledge of farmers on chickpea seed production, crop and seed health, and seed processing aspects in which 6,205 farmers (4,829 in Ethiopia, 521 in Tanzania, and 855 in Kenya); 114 extension personnel also participated. An information bulletin was published on improved chickpea technologies and seed production in Ethiopia (both in English and Amharic). Twelve participants - four each from Ethiopia, Kenya and Tanzania - took part in a one-month training course on "Chickpea Breeding and Seed Production" organized at ICRISAT-Patancheru during Jan-Feb 2008 and 2009. One MSc student from Ethiopia and two from Kenya are working on chickpea improvement research.

Introduction

Chickpea is grown in ESA countries namely Ethiopia, Tanzania, Malawi and Kenya and to a little extent in Eritrea, Sudan, and Uganda. During the last decade area under chickpea has been almost constant, hovering around 350,000 to 390,000 ha. Productivity was less than 700 kg per ha until 2006 (Table 8-1). Ethiopia is the major chickpea producer in the region occupying about 60% of the total area. Chickpea provides unique opportunity of enhancing legume production in Africa as it does not compete for area with other major legumes. Groundnut, cowpea, soybean and common bean are the wet season (rainy season) legumes, whereas chickpea is a dry-season (post-rainy season) legume. There is not much choice of legumes for growing on the residual moisture in the post-rainy season, the conditions and season in which chickpea is grown.

Chickpea is indeed a bonus crop in Kenya and Tanzania. After harvest of maize/wheat in Kenya or maize/rice in Tanzania, the land is normally left fallow until the next cropping season (rainy season). Chickpea is planted immediately after the harvest of cereals and grows under residual moisture thus giving farmers a second crop (where only one crop would traditionally be grown) hence income, and nutrition.

Further, policy makers and peoples' representatives in Kenya are also in favor of drought tolerant chickpea, and have earmarked constituency development fund to promote this crop. The bulk of chickpea produced in Eastern Africa is consumed locally, adding to the nutrition of people; only Ethiopia exports a substantial amount of its chickpea produced. Chickpea has more diversified uses than any other food legume. The green leaves are used as leafy vegetable and are superior to spinach and cabbage in mineral content. The green immature seed is used as a snack or vegetable. Selling green pods for green grains is highly profitable as these are sold around US $ 1 to US$ 1.5 per kg and weigh 2-3 times higher than dry grains. The dry seed splits and flour are used in a variety of other preparations like *githeri*, stew, *mandazi*, cake, *samosa*, doughnuts, buns, *chapati* and grits.

Table 8-1: Area, production and productivity trends in ESA and Ethiopia

Year	Area (000 ha)	Production (000 MT)	Productivity (kg per ha)
ESA [1]			
2001-03	*380.6*	*247.2*	*650*
2004-06	*358.2*	*246.5*	*687*
2006	371.9	264.4	710
2007	381.7	297.5	779
2008	389.7	327.1	837
2009	412.1	369.9	896
Ethiopia [2]			
2003-05	*174.3*	*168.0*	*964*
2006	200.1	253.9	1269
2007	226.8	286.8	1265
2008	233.4	312.1	1337

[1]= data source FAO, and [2]= data from CSA (Central Statistical Agency of Ethiopia)

Locations and partners

Three ESA countries were involved along with target districts/locations mentioned in Table 8-2.

Table 8-2: Project locations and partners for chickpea research in ESA

Country	NARS partner	Region/Province	Zone/district	District/division	Scientist
Ethiopia	EIAR/Debre Zeit	Oromia	E. Shewa	Gimbichu, Lume, Ejere	Asnake Fikre, Kebebew Assefa, Million Eshete, Nigussie Girma
		Amhara	N. Shewa	Minjar-Shenkora, Moretna-Jirus	
			N. Gondar	Debre-Tabor	
		SNNPR	Gurage	Sodo	
Tanzania	LZARDI, Ukiriguru	Mwanza	Lake Zone	Misungwi, Kwimba	Robert Kileo, Everina Lukonge, Epifania Temu, Joachim Joseph, Raphael Habai
			Shinyanga	Shinyanga, Kishapu	
Kenya	KARI-Njoro	Rift Valley	Bomet	Siongoroi, Longissa	Wilson M.Thagana, Ngari Macharia
			Nakuru	Gilgil, Naivasha	

Socio-Economics/Targeting

During the Phase 1 base line data conducted in Ethiopia provided very valuable information on several aspects of chickpea value-chain on production, seed systems and marketing. The summarized account of same are presented below.

Cropping pattern

Bread wheat and white tef were the most common crops produced among the 700 sampled households in Gimbichu (149), Lume-Ejere (300) and Minjar-Shenkora (251). When it comes to share of crop area allocated to improved varieties, kabuli chickpea takes the lead (42.5%) followed by bread wheat (36%). Desi chickpea is the third most popular crop produced by 53.6% of the sampled households.

Crop yields

The average yield for kabuli chickpea was relatively higher in Minjar-Shenkora district (3285 kg per ha) compared to the other two districts (Gimbichu-2374 kg per ha and Lume-Ejre-2389 kg per ha), whereas for desi chickpea there seems to be no yield difference across the three districts (Minja-Shenkora-1877 kg per ha, Gimbichu-1913 kg per ha and Lume-Ejre-1988 kg per ha).

Use of manure and fertilizers

Fertilizer used in chickpea was relatively much less than its use in wheat and tef. For kabuli, the average amount of DAP and urea used per ha amounts to 16 and 11 kg, respectively, whereas the amount used for desi chickpea was by far less (3.4 kg each of DAP and Urea). Manure application is also popular especially in Lume-Ejere and Minjar-Shenkora districts.

Chickpea seed access

The first major source of seed for Arerti and Shasho varieties was own saved seed followed by producers' groups. About 47% of those who planted Arerti and 50% of those who planted Shasho used their own saved seed for 2006/07 cropping season whereas about 33% and 26% of those who planted the same variety sourced seed from producer marketing groups or cooperatives. Own saved seed again was a vital source of seed for Chefe (77%), Worku (71%) and local desi (84%) varieties while producer marketing groups also contribute for Ejere type (33%). The third and fourth important sources of seed during the 2006/07 planting season were local seed producers and local traders and/or agro-dealers, respectively. The first and second major reason why some farmers never adopted the improved varieties was lack of access to seed and fear of theft during the green stage, respectively. The third and fourth major reasons are related to shortage of land and lack of cash to buy seed and/or lack of credit.

Use of purchased seed and other inputs

Only 48% of sampled households use at least some purchased seed, perhaps due to use of recycled seeds. The share of seed purchased for kabuli is about 48.9%, which was significantly higher compared to desi (3.1%). The average total labor used in person days is about 97 per ha for kabuli and 83 per ha for desi chickpea.

Chickpea utilization

Over 70% of kabuli chickpea and 55% of desi chickpea produced are sold in the market, suggesting the relevance of chickpea as a cash crop in the study area. Kabuli chickpea is the first crop primarily produced for the market compared to all other crops grown in the study regions. Desi chickpea takes the third rank in terms of share of produce sold in the market.

Crop-livestock interactions

About 10.5% of the sample respondents use crop residue as source of animal feed whereas about 5.5% use green fodder or grazing land.

Preferred traits for chickpea

The overall score for Chefe variety was the highest for both men and women chickpea farmers, followed by Ejere types. When we examine based on specific traits, female chickpea farmers prefer Arerti variety for their taste and high price in the market whereas male farmers prefer the same variety for high price and grain yield. Shasho variety is highly preferred for its high price in the market, grain size and grain color both by male and female farmers. Male farmers prefer Chefe for their grain color and size while female farmers prefer them for their high price in the market, grain size and low cost of production. The preferred traits for Ejere variety by both male and female farmers are high price in the market, grain size and grain color. Generally, kabuli varieties are highly preferred for their high economic return in addition to their grain color and size. Characteristics of Worku variety favored by male farmers include good taste and uniformity in maturity while female farmers prefer them for good taste, grain color and high price in the market.

Production pattern and productivity

The most widely grown kabuli variety among chickpea farmers remains Shasho (20.6%), followed by Ejere (11.7%) and Arerti (10%), respectively. Local desi remains the most widely grown variety among chickpea farmers while only 4.3% grow improved desi. Of the total chickpea area in the survey regions, about 54.5% is allocated to local desi followed by Shasho (21%) and Ejere (11.9%).

Net-return of chickpea

Generally kabuli varieties perform superior in terms of yield, compared to the desi types. Among all chickpea varieties Arerti and Shasho varieties have the highest gross margin in terms of returns to land and management. The average return for Arerti and Shasho is about ETB 10,283 and ETB 9,496 per ha, respectively, whereas improved desi has a net-return of about ETB 2,481 per ha.

Constraints to chickpea production and marketing in Ethiopia

The available high-yielding varieties with market-preferred traits have not reached farmers on a large scale. The local landraces grown by farmers do not meet the quality and quantity requirements preferred to some extent by domestic but especially international markets. Poor and inadequate seed systems, shortage of quality seed and lack of timely delivery is another major limiting factor for adopting new varieties, especially the kabuli types, and insufficient access to production credit to farmers. The supply originates in small quantities from several highly dispersed small producers that supply non-homogenous desi types to local markets. There is lack of a well-coordinated supply chain that links producers and buyers. There is no efficient mechanism for delivering market information to the producers and traders at local markets on issues related to seasonal prices, demand, and quality requirements in different markets across the country. There is lack of a well-established system of grades and standards in the chickpea marketing system. The desi chickpea varieties currently grown by farmers in the country are not able to satisfy the quality attributes required by diverse markets.

Post-harvest handling and consumption

About 86.4% of farmers who ever planted chickpea thresh their produce with animals on dung cemented surface and/or grass whereas about 13% thresh with animals on dirt surface. About 74% of Shasho andEjere varieties produced are sold in the market ranking first among chickpea varieties in terms of market share. Arerti and local desi take the second and third rank in terms of share of produce sold in the market. The proportion of improved and local desi sold in the market is about 20% and 55%, respectively. About 10% of all kabuli varieties produced are saved as seed for next cropping seasons while the share is a bit higher of desi types. Among the kabuli varieties, the share of produce used for home consumption is highest for Chefe (39%) followed by Arerti (25%). On the other hand, about 68% of improved desi and 32% of local desi produced by sampled households are used for home consumption.

Chickpea marketing

About37% and 64% of kabuli and desi chickpea farmers are involved in marketing, indicating its role as a source of cash. Within the kabuli category, the proportion of chickpea farmers involved in marketing of Shasho variety is the highest, followed by Ejere type. The marketed surplus for kabuli chickpea is a bit higher than desi types. About 74% of the chickpea are sold in the main market. Urban grain traders are the first major buyers of chickpea in all the three districts, followed by rural traders and rural assemblers.

Chickpea price trend in Ethiopia

Both producer and retail price are higher for kabuli chickpea than for desi types. The annual average rate of growth (ROG) of kabuli retail price (4.5%) is more than double the desi retail price (2.3%). On the contrary, the ROG of desi producer price (3.68%) is much higher than kabuli producer price (0.37%).

Grades and standards

About 75% of traders recognized kabuli chickpea as having two grades (Grade 1 and 2). For desi chickpea, the majority of the sample traders in the primary markets (70%) recognized only one quality grade for the commodity. The major quality traits used in markets to classify chickpea grades include grain color, grain size, presence of foreign matter and broken and shriveled seeds. The survey results indicate that at all market levels (except for desi in primary markets) quality seems to attract a price premium. On average, there was a margin of about ETB 27 per 100 kg for kabuli chickpea and ETB 15 per 100 kg for desi chickpea.

Gender aspect of chickpea production and marketing

Chickpea production is the responsibility of the household in general. In the study areas, men and women appear to make decisions regarding the sale of chickpea. Women are less familiar with modern markets and feel powerless to influence them. They are hampered by cultural norms, and the lack of access to information on new technology, prices, demand, etc. Unlike their husbands, they are rarely given training in modern small-business management. Also, they are hampered by factors common to all: lack of adequate transport and communications services, inadequate equipment and facilities in marketplaces and the presence of exploitative middlemen. Compared to women, men have easier access to technology and training, mainly due to their strong position as head of the household and greater access to off-farm mobility. Men have easier access to credit than women.

Sources of information, chickpea variety preference and adoption

The proportion of households receiving information about kabuli varieties from neighbors and government extension amount to 46.6% and 45.3%, respectively. The third most important source of information is farmer cooperative (26.1%). Neighbors remain the first major source of information (72.4%) for desi varieties followed by family members. Generally, kabuli varieties are highly preferred by chickpea farmers for their high economic return in addition to their grain color and size.

Fast-Tracking, Development, and Release of Varieties

Variety development

A number of segregating materials generated at ICRISAT-Patancheru received by ICRISAT-Nairobi and EIAR/Debre Zeit-Ethiopia in the form of international chickpea screening nurseries and other evaluation trials. After preliminary evaluation in Kenya, elite materials shared with the NARS programs in Tanzania (LZARDI-Ukiriguru) and Kenya (KARI-Njoro and Egerton University).

ICRISAT-Nairobi received 123 lines of heat tolerance nursery (61 desi and 62 kabuli) and supplied best lines of desi (ICCVs 07101, 0712, 07104, 07110, 07114) and Kabuli (ICCVs 07304, 07308, 05312, 07306, and 05315) to Kenya and Tanzania. Seventeen desi and 17 kabuli genotypes were evaluated in Tanzania and KARI-Njoro and identified superior genotypes in desi (ICCVs 97406, 07304) and kabuli (ICCV ICCV 07112, ICCV07110, and ICCV 07114) for further evaluation. Through multi-year and -country evaluation selected best genotypes for on-farm evaluation (ICCV 97126, ICCV 97031, ICCV 97128, ICCV 97125-desi; ICCV 97306, ICCV 00302, ICCV 97406, and ICCV 92311-kabuli).

Similarly, evaluated 84-desi and 60-kabuli genotypes at ICRISAT-Nairobi and noted very good genetic diversity for larger seed size among Kabuli. Same set of 144 genotypes were evaluated in Ethiopia that facilitated to identify potential genotypes with seed mass significantly higher than present day high yielding varieties(like ICCV 92318) coupled with higher grain yield(Table 8-4).

Table 8-3: Details of nurseries evaluated

Location	Nursery/# of lines
ICRISAT-Nairobi	Heat tolerant/123
Kenya: KARI-Njoro, Egerton University	Two kabuli/37, two desi/34
Tanzania: LZARDI-Ukiriguru	Two kabuli/37, two desi/34
Ethiopia: EIAR-Debre Zeit	Desi/84, kabuli/60

Table 8-4: Promising new generation large-seeded Kabuli types evaluated in Kenya

Name	Days to 50% flowering	Days to 75% maturity	100 seed mass (g)	Yield (kg per ha)
K032	48	106	61.7	3458
ICCV 08313	42	104	51.5	3181
K034	44	113	49.7	3595
ICCV 08308	42	110	48.7	3748
K025	47	109	48.5	3094
K021	50	107	47.5	3863
K026	43	111	47.0	3494
ICCV 08302	44	111	46.5	3368
ICCV 92318(Check)	**43**	**105**	**35.8**	**2846**

Variety release

In ESA target countries, a total of 9 varieties have been released during the project period as per the details below (Table 8-5).

Table 8-5: Chickpea varieties released in ESA

Variety	Popular name	Type	Year	Country	Average on-farm yield (kg per ha)	Yield advantage over checks (%)
ICCV 97105	Ukiriguru 1	Desi	2011	Tanzania	1456	46
ICCV 00108	Mwanza 1	Desi	2011	Tanzania	1432	43
ICCV 00305	Mwanza 2	Kabuli	2011	Tanzania	1536	54
ICCV 92318	Mwanza	Kabuli	2011	Tanzania	1192	19
ICCV 03107	Minjar	Desi	2010	Ethiopia	1500-4000	43
ICCV 00108	NA	Desi	2009	Kenya	2030	18
ICCV 00305	NA	Kabuli	2009	Kenya	1800	5
ICCV 97105	NA	Desi	2010	Kenya	2400	40
ICCV 95423	NA	Kabuli	2010	Kenya	2250	31

Identification of farmer- and market-preferred chickpea varieties

A total of 186 farmers participatory varietal selections (PVS) trials were conducted in three Ethiopia(68), Tanzania (47) and Kenya (71); and 3,087 farmers (Ethiopia 2611, Tanzania 318, Kenya 569) participated. In addition, 525 field demonstrations in Ethiopia were organized to disseminate promising varieties and production technologies. During the PVS 6-11 /released or pre-released varieties were included along with a farmer's variety as a check (Table 8-6). Farmers came up with a number of preferred traits such as early maturity - to avoid end season drought and reach the market while the prices are still high; vegetable type for local niche markets; high yield potential; profuse podding; large seed size for domestic consumption/local and international markets; resistance to terminal drought, *Fusarium* wilt and *Ascochyta* blight (in Ethiopia). A few gender-wise differences in preference were observed, with men going for market traits such as grain size, and women for consumption and green pods (Table 8-7).

Table 8-6: Varieties used in PVS trials over 3 years

Country	Name of varieties		
	Desi	Kabuli	Check
Ethiopia	Natoli, ICCV 03107	Ejerie, Teji, Shasho, Chefe, Mastewal, Arerti, Habru, Gabo, Acos Dubie (Monino), DZ-10-04	Farmer variety
Tanzania	ICCV 97105, ICCV 00108	ICCVs 00305, 97306, 96329, 92318	Dengumawe (local desi)
Kenya	ICCV 97105, ICCV 00108	ICCVs 00305, 97306, 96329, 95423	Ngara Local (desi)

Table 8-7: Farmer-preferred varieties in the three countries

Country	Desi	Kabuli
Ethiopia	Natoli	Habru, Ejere, Arerti, ACOS-Dube
Tanzania	ICCV 00108, ICCV 97105	ICCV 92318, ICCV 00305
Kenya	ICCV 97105, ICCV 00108	ICCV 95423, ICCV 00305

Seed Production and Delivery Systems

In ESA, baseline studies indicated that very limited awareness existed on improved chickpea varieties, due to consistent failure of public sector to supply good quality source seed and the lack of interest by the private sector to engage in legume seed production; in addition, most often, seed is produced in high potential areas or areas with infrastructure for storage and processing far away from its area of utilization, leading to high transaction costs. Requirements for high seeding rates further limit the spread of new varieties.

To overcome these constraints, investments have been made in Breeder and Foundation seed production, and proceeds from seed sales were employed to re-capitalize seed revolving funds to support subsequent seed production cycles. Foundation seed has been marketed to private companies and NGOs for further seed production and dissemination. Most of the farmers rely on own-saved seed and access to seed of improved varieties either through informal networks or relief seed. The survey also revealed that existence of two seed supply systems, i.e. informal, which are usually non-market based seed supply systems and the quasi-formal, mainly market-based seed supply systems. The informal seed supply sources included own saved seed; gifts from family and friends; farmer-to-farmer seed exchanges and others. The importance of quasi-formal seems to increase with the availability of new farmer-preferred varieties, which helps in emergence of seed markets for improved varieties.

During the past four years (2007-10) a total of 31.7 MT Breeder Seed and 3,602 MT Foundation and Certified seed of farmer-preferred improved chickpea varieties was produced at research stations and farmers' fields (Tables 8-8 & 8-9).

Table 8-8: Various classes of quality seed produced in ESA (MT)

Country	No. of varieties	Breeder	Foundation	Certified	Total
Ethiopia	9	22.4	211.6	3,353.2	3,616.3
Tanzania	5	1.67	37.7	-	39.37
Kenya	6	1.2	-	-	1.2
ICRISAT-Nairobi	9	6.43	-	-	6.43
Total	**29**	**31.7**	**249.3**	**3,353.2**	**3,663.3**

Table 8-9: Seed production by variety in Ethiopia (MT)

Variety	Tolerance to/special trait(s)	Breeder	Foundation	Certified	Total
Arerti	*Ascochyta*, *Fusarium* wilt	8.7	105.8	2313.5	2447
Shasho	*Fusarium* wilt	2.4	47.4	534.9	594.5
Marye	Moisture stress	1.1	9.0	419.5	429.6
Habru	*Ascochyta*, drought	3.4	18.8	52.8	75.1
Ejere	*Ascochyta*, drought	2.3	16.0	32.5	50.8
Teji	High yield in potential areas	1.1	3.7	0.0	4.8
Natoli	High yield in potential areas	1.6	6.9	0.0	8.5
Minjar	*Ascochyta*, *Fusarium* wilt, high yield	0.8	2.0	0.0	3.0
ACOS Dubie	Bold seed size	1.0	2.0	0.0	3.0
Total		**22.4**	**211.6**	**3,353.2**	**3,616.3**

Table 8-10: Seed production by variety in Tanzania (MT)

Variety	Tolerance to/special trait(s)	Breeder	Foundation	Total
ICCV 92318	Early maturing, wilt resistant	0.30	24.20	24.50
ICCV 00108	Wilt resistant	0.57	1.00	1.57
ICCV 00305	wilt resistant	0.35	1.00	1.35
ICCV 95423	Early maturing	0.00	10.50	10.50
ICCV 97105	Wilt resistant	0.45	1.00	1.45
Total		**1.67**	**37.70**	**39.37**

Seed production delivery strategies

Various seed production and delivery strategies have been tried for various seed classes. The most effective ones are summarized in Table 8-10.

Table 8-11: Effective seed systems identified for chickpea production in Ethiopia and Tanzania

Seed class	Ethiopia	Tanzania
Breeder Seed	Research centers	Research centers
Foundation Seed	Farmers' coops, private sector, NGOs	Farmer-Field-Schools, private sector, NGOs
Certified Seed	Specialized smallholder farmers	Farm organizations
Quality Declared Seed	Farmers, farm organizations	Farmers, farm organizations

Two NGOs in Tanzania and three in Ethiopia were involved in seed production and distribution. In Ethiopia, Farmers' Cooperative Unions were involved in seed production and distributed 25 MT of Foundation Seed to members. In addition, a grain exporting company known as ACOS (Agricultural Commodities and Supplies) was involved in the multiplication, marketing, and export of chickpea, using smallholder farmers as out-growers.

Draft seed business plans have been completed. Three seed delivery seed systems targeting smallholders, such as seed revolving fund facility, community seed banks, and farmer field schools were tested. Three seed marketing groups - Mpeta, Mnanje B and Likokona - have been established in Tanzania.

Community-based seed production and marketing systems such as Quality Declared Seed (QDS), which is tested in Tanzania for dissemination of truthfully labeled seed of high quality could be one strategy for easing the seed shortage problem, especially for self-pollinated legumes like chickpea. The private sector lacks the incentive to participate in the enhanced delivery of seeds of these crops as the size of the market is small and farmers are able to use recycled seed for 3-5 years. Strengthening the on-going farmer-based seed production program and revolving seed scheme by improving farmers' skills in seed multiplication can assist in increasing the supply of seed for improved varieties both within communities and to the formal seed system. The revolving seed scheme, where target farmers are often organized into groups or cooperatives, accesses a certain amount of seed of improved varieties from a supplier (e.g. NGO or Ministry of Agriculture) and returns at least the same amount of seed in-kind, is an important mechanism in the absence of adequate supply of improved seed to reach all farmers. Currently, the scheme is run for disseminating improved varieties by the district agricultural offices although there is a possibility to involve cooperatives.

Capacity Building

Training of farmers

Training was provided to 6,205 farmers on various aspects of improved crop and seed production, seed storage and utilization technologies of chickpea in Ethiopia (4,829), Tanzania (521) and Kenya (855).

Field days, farmers' fairs

In total, 25 field days were conducted in target locations of Kenya (11), Tanzania (8) and Ethiopia (6) with participation of 2,523 farmers (Kenya-855; Tanzania-958; Ethiopia-710). During the field days farmers were asked to select preferred varieties along with preference criteria. The comprehensive analysis from this activity facilitated the release of the new varieties in each country and helped in planning for seed production strategy. Farmers' preference criteria also provided feedback to researchers and development personnel involved in chickpea to devise the research strategy for Phase II. In Kenya, researchers along with human nutritionists also demonstrated the utility aspect of chickpea in the form of various products such as chapati, *githeri*, stew, *mandazi*, cake, *samosa*, doughnuts, buns, grits, and beverage and elicited feedback on preferred products (*githeri* and stew).

Awareness activities

Awareness activities were conducted through radio, television, newpaper, popular articles and telephone conversations. PVS village network, demonstrations, annual farmer field days, rural seed fairs, and agricultural shows were used in awareness creation. In Kenya, policymakers were engaged in awareness creation. Proceedings of all the field days were broadcast on public media (Ethiopian Television, Ethiopian Radio, Ethiopian News Agency, and newspapers) in Amharic, Oromifa and English. Television and radio broadcasts with live interviews and newspaper articles about new varieties have become a norm throughout the project sites in Tanzania. Information bulletin on 'Improved chickpea technologies and seed production in Ethiopia' was produced and shared with all the stakeholders. Manuals in seed production also produced in Swahili (Tanzania). Flyers describing chickpea have been printed in Amharic and Swahili and distributed to farmers in project sites (more than 5,000 flyers).

Training of extension personnel

A total of 114 MoA staff and NGO's were trained as master trainers on chickpea production technology (Table 8-12).

Table 8-12: Details of participation in production technology

Country	Training focus	Participants
Tanzania	Chickpea production and storage, PVS approach and facilitation, basic data collection skills	48 extension and collaborating NGOs staff
Ethiopia	Chickpea production technology	30 Subject Matter Specialists /Development Agents from *Wereda* Bureau of Agriculture
Kenya	Chickpea production technology and utilization	36 extension staff

Similarly, 26 officers, 64 development agents, 22 farmers, 50 research technicians and 110 extension officers were trained in seed production and management in Ethiopia.

A total of 120 farmers (78 men and 42 women) from three districts of Tanzania participated in one-day training on seed farm management, processing and grading of Quality Declared Seed. Four field days on chickpea scaling up and demonstration were held in Ethiopia with participation of 455 farmers, 30 agricultural officers, 10 research technicians, 10 technical assistants, 20 officers from Ministry of Agriculture and Rural Development (MoARD), one from the Ethiopian Seed Enterprise, three representatives of Farmers, Cooperatives Unions, and other stakeholders.

Training of scientists and research technicians

A one-month training course on "Chickpea Breeding and Seed Production" was organized at ICRISAT-Patancheru during Jan-Feb 2008 and 2009, involving 12 participants (Table 8-13) from ESA, i.e. four each from Ethiopia, Kenya and Tanzania. The topics covered included on whole range of topics starting from reproductive biology, crossing, breeding methods (conventional and biotechnological, conduct of multilocational trials, data collection, resistance breeding, quality seed production and safe seed storage. The participants also had opportunity to visit other organizations in Hyderabad working on seed-related research, seed production, and seed quality testing.

Table 8-13: Details of training participants from ESA

Name	Gender	Country	Affiliation	Year
Mussa J. Hedo	Male	Ethiopia	Debre-Zeit	2008
Ketema D. Abdi	Male	Ethiopia	Debre-Zeit	2008
Robert O. Kileo	Male	Tanzania	LZARDI-Ukiriguru	2008
Everina P. Lukonge	Female	Tanzania	ART-Ukiriguru	2008
Paul K. Kimurto	Male	Kenya	Egerton University	2008
Peter Kaloki	Male	Kenya	ICRISAT-Nairobi	2008
Million Eshete	Male	Ethiopia	Debre-Zeit	2009
Abebe Atilaw	Male	Ethiopia	Debre-Zeit	2009
Epifania E. Temu	Female	Tanzania	LZARD-Ukiriguru	2009
Stella G. Chirimi	Female	Tanzania	LZARD-Ukiriguru	2009
Bernard K. Towett	Male	Kenya	Egerton University	2009
Wilson M Thagana	Male	Kenya	KARI-Njoro	2009

Development of infrastructure facilities

In all, the target countries' basic infrastructure facilities at the farm level have been established/upgraded to ensure proper conduct of experiments and assured seed multiplication, as given below:

- KARI-Njoro: Renovation of existing irrigation facilities to produce seed under assured irrigation both during main and off-seasons;

- LZARDI-Ukiriguru: Land along with proper fencing was developed exclusively for chickpea yield trials/nurseries and seed multiplication; and
- EIAR-Debre Zeit: Irrigation facility for off-season seed multiplication.

Degree students

One MSc student from Ethiopia (Tadesse Sefera) completed his thesis research on molecular characterization of Ethiopian chickpea varieties and defended his thesis at Harmaya University, Ethiopia. In addition to these, we have two MSc students from Kenya; one is working on heat tolerance (Peter Kaloki) and another (Nancy Wathimu Njogu) on *Helicoverpa* resistance in chickpea (Table 8-14).

Table 8-14: Degree students working on chickpea research

Name	Country	Program	University	Research area
Peter Kaloki	Kenya	MSc	University of Nairobi, Kenya	Identification of sources of heat tolerance in chickpea
Tadesse Sefera	Ethiopia	MSc	Haramaya University, Ethiopia	Genetic diversity analysis and DNA fingerprinting of chickpea varieties using simple sequence repeat (SSR) markers
Nancy Njogu	Kenya	MSc	Egerton University	Genetic variability for resistance to *Helicoverpa armigera* in chickpea

Lessons learned

General (all countries)

- Farmers' awareness of the improved varieties and availability of the seed of improved varieties are the key factors in the spread of improved chickpea varieties;
- Conduct of PVS, field days and seed fairs are very effective in awareness creation among farmers about new varieties and generate sustained seed demand;
- The farmers need some orientation and close follow up for their active participation in PVS trials;
- Farmers participation in varietal selection reduces the time required for varietal testing and possible high adoption of tested varieties before or after formal release;
- In addition to yield, maturity duration and resistance to diseases, seed traits preferred by market (seed size, color and shape) were also given high weightage by farmers in th selection of improved chickpea varieties. Thus, market-preferred traits are also important for adoption and up-scaling for improved chickpea varieties;
- The farmers' preferences for growing kabuli chickpea varieties largely depended on the price premium received over desi type;
- Individual farmers are often reluctant to become seed growers due to lack of capabilities for seed processing and storage and difficulties in marketing. However, they were very keen to take seed production of improved varieties provided arrangements were made for assured procurement of seed. Community Seed Producer Associations may be promoted and could have better access to seed processing and storage facilities and marketing;
- Sustainable seed production by smallholders stands a better chance of success if complimented by functional seed and product markets;

- Project interventions should focus on smallholder-centered seed production and delivery systems that have a better chance of surviving beyond the lifespan of the project;
- Business-oriented small holder farmers perform better in seed production, storage, and dissemination than food security-oriented farmers, hence these group of farmers should be involved in seed systems; and
- Limited number of researchers and technicians available in ESA also hampers progress of varietal development and seed dissemination.

Country-specific

Ethiopia

- Shortage of initial seed of new varieties was a major bottleneck in promoting new varieties in Ethiopia;
- Off-season seed multiplication with supplemental irrigation facilitated faster varietal spread in Ethiopia. Infrastructure for irrigation needed to be strengthened;
- Active participation of Department of Agriculture staff was essential in the successful implementation of demonstrations both in number and size;
- Project progress in target regions generated greater interest in chickpea adoption in nearby North Shewa and North Gonder Zones.

Tanzania

- Project progress initiated a momentum for formal release of varieties;
- Need for strengthening farmers seed producer groups for seed production; and
- Farmers in general prefer desi types because traders are used to it and also high domestic demand for desi types.

Kenya

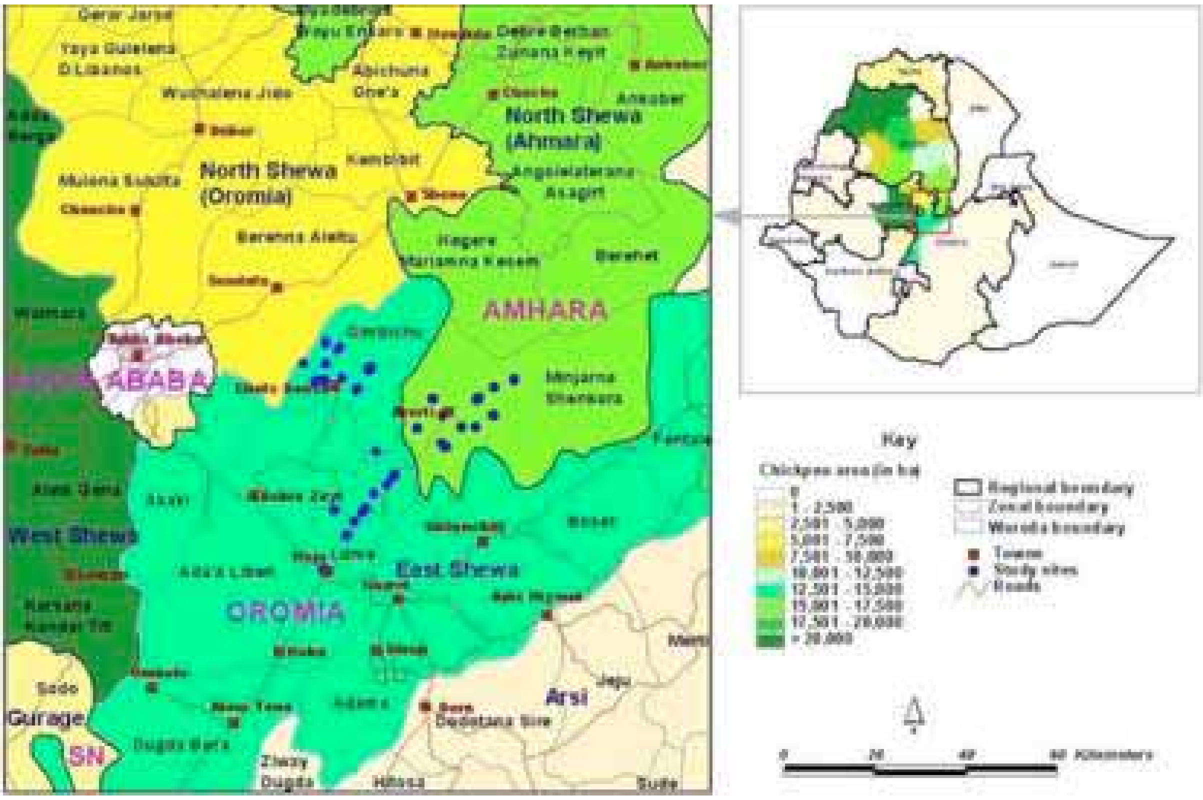
- In Kenya, chickpea was identified to have higher drought tolerance compared to maize and beans, indicating high potential for enhancement of area, particularly in the arid and semi-arid areas with vertisols;
- Sensitization of policy makers about the importance of chickpea in combating drought has helped in getting their support in this country and this has provided a boost to our efforts in enhancing chickpea area; and
- Better performance of chickpea under prevailing drought conditions created awareness among farmers, policy makers, MoA staff and consequently a greater demand for seed.

Vision for second phase

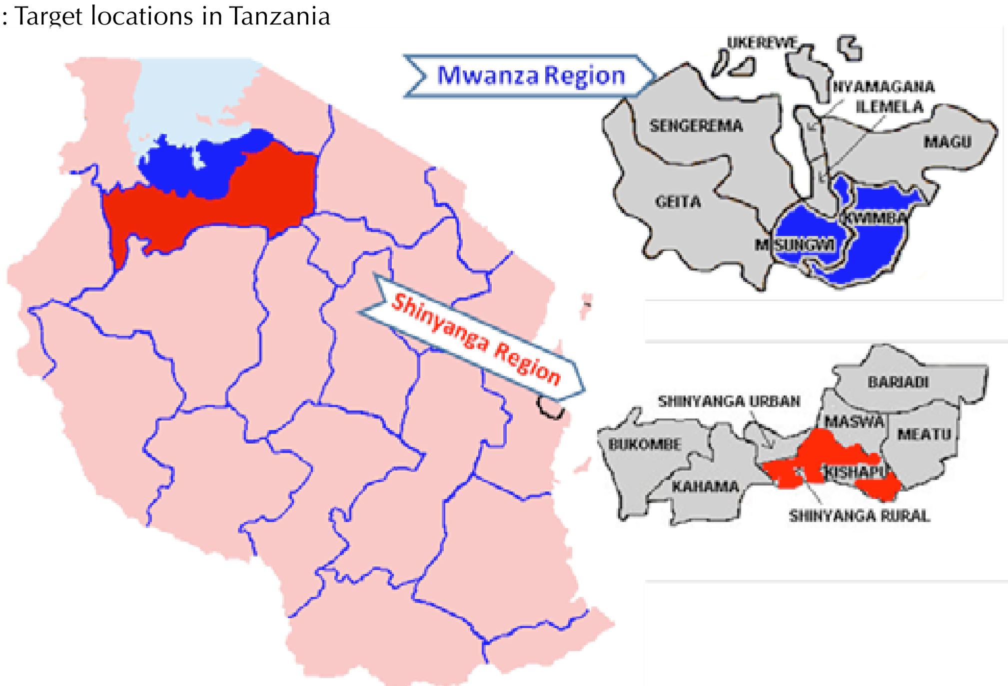
- The countries will remain the same. However, the activities will be expanded to new districts within the existing states/zones/regions and to additional states/zones/regions;
- Seed system will be further strengthened based on the experiences of Phase I;
- The breeding materials generated through genomic approaches (MABC and MARS) under TL I will be evaluated along with breeding material generated under TL II in target environments;

- Establishing functional legume value-chains to stimulate seed demand;
- Seed production manuals published, awareness created through PVS, new varietal releases – fosters better seed systems in second phase; and
- Strengthening linkages between researchers, seed producers, agro-dealers, and private large scale entrepreneurs for greater impact.

Annex 8-1: Chickpea distribution and target sites in Ethiopia



Annex 8-2: Target locations in Tanzania



Pigeonpea Breeding and Seed Systems in India

KB Saxena, MG Mula (ICRISAT-Patancheru, India); AN Patil(PDKV-Akola, Maharashtra, India); CV Sameer Kumar (ANGRAU, Hyderabad, Andhra Pradesh, India)

Breeding

Summary

The activities for pigeonpea were carried out in Maharashtra (Akola and Washim districts) and Andrha Pradesh (Ranga Reddy district) with active participation of the KrishiVigyan Kendra (KVK) Durgapur taluk, Murtizapur and Karda taluk Risod (Maharashtra) and Agricultural Research Station (ARS) of Acharya N.G. Ranga Agricultural University (ANGRAU), Andhra Pradesh (AP). The villages were selected in consultation with program coordinators. Progressive farmers from the selected villages were identified for conducting of mother and baby trials of farmers participatory varietal selection trials (PVS). Preferred traits of pigeonpea were selected with emphasis on wilt resistant, medium bold size, red-seeded and suitability of variety for intercropping with crops like soybean, cotton, mung and urd beans. The preference of the improved varieties varied from village to village, depending on soil type, cropping system and existing disease problem (wilt, sterility mosaic disease). In project villages (Maharashtra), the demand of PKV-TARA, BSMR-736, BDN-708 and Vipula was more as compared to other varieties. ICPH 2671, although having higher yield, was relatively less preferred by farmers due to the dark color of the seed. In AP, the farmers preferred varieties due to their resistance to wilt/sterility mosaic diseases and higher yields such as Asha, PRG 158 and ICPH 2671.

PVS trials

During the three year period of the project, a total of 10 mother trials and 107 baby trials were conducted. In Maharashtra, six mother trials and 91 baby trials were implemented in 15 villages of Akola and Washim districts, while in AP, 16 baby trials and four mother trials were conducted in 16 villages of Ranga Reddy and Mahaboobnagar districts. Varieties tested were Asha, Maruti, Lakshmi, LRG 41, PRG 158 and ICPH-2671 with NallaKandi as local check for AP while in Maharashtra, PKV TrombayTur, AKT-8811, ICPH 2671, BSMR-853, BDN-708, and Vipula.

The overall assessment of the mother and baby trials in Maharashtra revealed that ICPH 2671 (hybrid) performed best with yield of 2.8 MT per ha, followed by PKV TrombayTur (1.9-2.0 MT per ha), BDN 708 (1.6-1.8 MT per ha), AKT 8811 and Vipula (1.2-1.5 MT per ha) and BSMR 853 (1.3-1.4 MT per ha). In AP, Asha, ICPH 2671 were the preferred varieties.

Mother trials

In Maharashtra, the mother trials were conducted under an intercropping system in rain-fed conditions. A total of six trials (2 in each district and 1 trial at each of the KVK) were conducted. Out of the five locations Maruti ranked first in four villages as preference given by the farmers at the time of field days/on-farm training. In village Shelu-khadase PKV Tara variety is preferred. Moreover, the overall assessment shows that PKV Tara/Vipula stand second in preference (Table 9-1). In AP, Kodangal and Basheerabad farmers preferred Asha and ICPH 2671 among the other varieties (Table 9-2).

Table 9-1: Farmers' preferred varieties identified from mother trials in Maharashtra

Village, District	**Preferred varieties**		
	I	**II**	**III**
Kanzara, Akola	Maruti (84.0)	BSMR-736 (72.0)	ICPH-2671 (28.0)
KVK Durgapur, Akola	Maruti (89.7)	PKV Trom. Tur (81.0)	Vipula (60.3)
Nipana, Akola	No data	No data	No data
Shelu-Khadase, Washim	Maruti (82.6)	Vipula (60.9)	BSMR-736 (54.4)
Shelgaon-Ingole, Washim	PKV Tara (90.6)	Vipula (77.4)	AKT-8811 (58.5)
KVK Karda, Washim	Maruti (90.5)	Vipula (73.8)	ICPH-2671 (63.1)

Note: Figures in parentheses indicate percent preference

Table 9-2: Mother trials conducted in AP

Location	Cultivar	Disease incidence (%)			Insect incidence		Yield (kg per ha)	Preferred varieties
		Phytopthora Blight	Fusarium Wilt	SMD	*Helicoverpa armigera*	*Maruca*		
Kodangal, Mahaboobnagar	Asha,	None	None	None	Negligible	Negligible	960	Asha, ICPH 2671
	Maruti,	None	None	25	Negligible	Negligible	800	
	Lakshmi,	None	20	30	Negligible	Negligible	700	
	PRG 158	None	10	40	Negligible	Negligible	720	
	LRG 41	None	20	25	Negligible	Negligible	820	
	ICPH 2671	None	None	no	Negligible	Negligible	970	
	Local	None	20	25	Negligible	Negligible	600	
Naacharam, Mahaboobnagar	Asha	None	None	None	Negligible	Negligible	1120	PRG 158, Maruti, Asha
	Maruthi	None	None	None	Negligible	Negligible	1100	
	Lakshmi	None	10	None	Negligible	Negligible	950	
	PRG 158	None	None	None	Negligible	Negligible	1120	
	LRG 41	None	None	None	Negligible	Negligible	1070	
	ICPH 2671	None	None	None	Negligible	Negligible	550	
	Local	None	20	None	Negligible	Negligible	500	
Parvathpally. Ranga Reddy	Asha,	None	None	None	Negligible	Negligible	1230	Asha, ICPH 2671
	Maruti,	None	None	None	Negligible	Negligible	1050	
	Lakshmi,	None	10	25	Negligible	Negligible	970	
	PRG 158	None	no	35	Negligible	Negligible	1160	
	LRG 41	None	40	25	Negligible	Negligible	1010	
	ICPH 2671	None	5	10	Negligible	Negligible	1245	
	Local	None	60	60	Negligible	Negligible	780	
Tandur, Ranga Reddy	Asha	None	None	None	Negligible	Negligible	1350	Asha
	Maruti	None	None	25	Negligible	Negligible	875	
	Lakshmi	None	10	30	Negligible	Negligible	920	
	PRG 158	None	None	40	Negligible	Negligible	960	
	LRG 41	None	40	25	Negligible	Negligible	870	
	ICPH 2671	50	None	None	Negligible	Negligible	800	
	Local	None	60	60	Negligible	Negligible	600	

Baby trials

A total of 91 trials were conducted in intercropping systems under rain-fed conditions at Vidharba region (6 trial x 4 village x 2 resource divisions x 2 districts) of Maharashtra. Six trials in each of the 15 selected villages of two districts (Shelu-Khadse, Bhokarkheda, Sawad, Chinchamba Pen, Shelgaon-Ingole, Karanji, Dudhala, Borala, Kurum, Kanzara, Hirpur, Sirso, Agar, Nipana and Sukli-Khurd). ICP-8863 (Maruti) was used as a standard check in all these trials. Of the total 91 trials conducted, 18 trials were located in Akola taluk, three in Murtizapur taluk, four in Risodtaluk and three in Malegaon taluk failed for various reasons such as erratic and sporadic rainfall at project locations, long dry spell of 22-25 days after the emergence of the crop, poor management practices and lack of irrigation facilities at farmers fields. Results showed that farmers' preferences differed by location; however, wherever ICPH 2671 and Asha is planted, these varieties were preferred by farmers (Table 9-3).

In AP, Asha and ICPH 2671 were identified by farmers as the preferred varieties due to high yield and resistance to pests and diseases as shown in Table 9-4.

Screening breeding lines against drought

Forty eight breeding lines were received from ICRISAT and planted at Pulses Research Unit, Dr. PDKV, Akola, and Maharashtra. The varieties Asha, BSMR-736, Vipula, Maruti and BDN-708 were preferred by farmers in different villages. The sample of 1 kg seed of these varieties was distributed to 240 farmers in seven villages of Akola and Washim districts for multiplication. The preference of these lines is presented in Table 9-5. Among these lines, ICPB-2043, ICPB-2092, ICPL-20108, and ICPL-150 were found superior in respect of yield, wilt and SMD. In terms of reaction to SMD, the incidence was recorded in the range of 0.0 to 84.6% with susceptible SMD infection ICPB 2043, ICPB 2092 showed highly resistant reaction against SMD.

Seed Production and Delivery Systems

Summary

A total of 141.67 MT seed of various categories (Breeder, Foundation, Certified, and Truthfully Labeled) was produced by NARS in Andhra Pradesh and Maharashtra. The Certified and TL seed production program of farmer-preferred varieties in Maharashtra and Andhra Pradesh was undertaken at village level. The concept of 'one village-one variety' was successfully promoted in Gorvha village in Akola district in Maharashtra with variety ICP 8863 (Maruti). However, this concept could not be implemented successfully in other villages (Tiptala in Akola district and Karanji, Shelgaon Omkargir and Sukanda in Washim district) in spite of conducting the promotional meetings due to the reason such as pigeonpea intercrop with cotton was not permitted for seed certification (by seed certification agency), different varieties are supplied under production management packages and farmers were reluctant in executing the Certified Seed production program.

To facilitate efficient seed production and marketing, PDKV-Akola established linkages with Maharashtra State Seeds Corporation Limited (MSSCL) and Krishi Vigyan Kendras (KVKs) at Karda and Durgapura. In Andhra Pradesh, ANGRAU-Hyderabad established linkages with Andhra Pradesh State Seed Development Cooperation (APSSDC) and Adarsh Rythu for the efficient seed diffusion. The involvement of APSSDC and Andhra Pradesh State Seed Certifying Agency (APSSCA) in roguing, inspection and selection, and certification of farmers' seed production fields ensured the purity and quality of pigeonpea seed. However, in Maharashtra, there is a need to strengthen informal seed sector through the approach of 'seed village concept' where 'one village- one variety' strategy should be popularized because formal seed sector cannot lead to supply huge quantity of quality seed.

Table 9-3: Baby trials conducted in Maharashtra

Location	Cultivar	Yield (kg per ha)	Preferred cultivar	Location	Cultivar	Yield (kg per ha)	Preferred cultivar
Hirpur, Akola	Maruti	440	Vipula, BDN 708	Karanji, Washim	Maruti	830	Asha, ICPH 2671
	BDN 708	540			BDN 708	910	
	Asha	470			Asha	1020	
	BSMR 736	305			BSMR 853	740	
	ICPH 2671	500			BSMR 736	870	
	Vipula	555			ICPH 2671	1110	
	AKT 8811	270			Vipula	910	
	PKV TromTur	520			PVK Tara	920	
Kurum, Akola	Maruti	780	AKT 8811, BSMR 736		AKT 8811	780	
	BDN 708	710		Shelgaon-Ingole, Washim	Maruti	1140	Asha, Maruti, AKT 8811
	AKT 8811	1060			BSMR 736	1040	
	Asha	780			AKT 8811	1350	
	Vipula	720			Asha	1480	
	BSMR 736	840			BDN 708	1030	
	BSMR 853	710			Vipula	1650	
	PKV TromTur	700			BSMR 853	1110	
Kanzara, Akola	Maruti	1350	Asha, Maruti, BSMR 736, Vipula		PKV Tara	1700	
	Asha	1480		Dudhala, Washim	Maruti	880	ICPH 2671, Asha
	Vipula	1290			ICPH 2671	1100	
	AKT 8811	860			Asha	1080	
	BSMR 853	1080			Vipula	920	
	BSMR 736	1320			BSMR 853	730	
	ICPH 2671	920			BSMR 736	840	
Sirso, Akola	Maruti	640	Vipula, ICPH 2671		BDN 708	750	
	ICPH 2671	700			AKT 8811	670	
	BSMR 853	650			PVK Tara	870	
	AKT 8811	550		Sawad, Washim	Maruti	1040	PKV Tara, ICPH 2671, Vipula, Asha
	Vipula	740			BDN 708	860	
	BDN 708	520			Asha	1320	
	PKV Tara	560			Vipula	1440	
Agar, Akola	Maruti	310	Vipula, Maruti, PKV Tara		ICPH 2671	1250	
	Asha	300			BSMR 853	910	
	BSMR 853	270			PKV Tara	1420	
	Vipula	320			AKT 8811	890	
	PKV Tara	310			BSMR 736	1050	
Bhokar-Kheda, Washim	Maruti	970	ICPH 2671, Asha, Vipula	Borala, Washim	Maruti	1090	Vipula, ICPH 2671, PKV Tara, BSMR 738
	Vipula	1040			Asha	1300	
	ICPH 2671	1220			Vipula	1460	
	AKT 8811	850			ICPH 2671	1620	
	PKV Tara	980			BDN 708	950	
	Asha	1050			PKV Tara	1560	
	BDN 708	850			AKT 8811	1050	
	BSMR 853	750			BSMR 736	1310	
Shelu-Khadase, Washim	Maruti	960	ICPH 2671, Asha, PKV Tara, Vipula	Chinchamba Pen, Washim	Maruti	790	ICPH 2671, Asha
	Asha	1140			ICPH 2671	1150	
	BDN 708	560			BSMR 853	770	
	Vipula	1040			Asha	940	
	ICPH 2671	1240			PKV Tara	840	
	PKV Tara	1100			Vipula	950	
	BSMR 853	830					

Table 9-4: Baby trials conducted in AP

Location	Cultivar	Disease incidence (%)			Insect incidence		Yield (kg per ha)	Preferred cultivar
		Phytophthora Blight	Fusarium Wilt	SMD	*Helicoverpa armigera*	*Maruca*		
Parvathpally, Ranga Reddy	Asha	None	None	None	Negligible	Negligible	1190	Asha, ICPH 2671
	ICPH 2671	None	10	15	Negligible	Negligible	1270	
	Local	None	55	60	Negligible	Negligible	640	
Marpally, Ranga Reddy	Asha	None	None	None	Negligible	Negligible	1230	Asha
	Maruti	None	10	None	Negligible	Negligible	870	
	Local	None	20	None	Negligible	Negligible	520	
Manthti, Ranga Reddy	Asha	None	None	None	Negligible	Negligible	1350	Asha
	PRG 158	None	20	Negligible	Negligible	Negligible	970	
	Local	None	85	None	Negligible	Negligible	320	
Damarched, Ranga Reddy	Asha	None	None	None	Negligible	Negligible	1260	Asha
	Lakshmi	None	None	None	Negligible	Negligible	1020	
	Local	None	60	None	Negligible	Negligible	475	
Tandur, Ranga Reddy	Maruti	None	None	None	Negligible	Negligible	1210	Maruti
	Lakshmi	None	20	None	Negligible	Negligible	990	
	Local	None	85	None	Negligible	Negligible	320	
Belkatur, Ranga Reddy	Asha	None	None	None	Negligible	Negligible	1060	LRG 41
	LRG 41	None	None	None	Negligible	Negligible	1250	
	Local	None	60	None	Negligible	Negligible	575	
Rampur, Ranga Reddy	Maruti	None	None	None	Negligible	Negligible	760	PRG 158
	PRG 158	None	None	None	Negligible	Negligible	1270	
	Local	None	60	None	Negligible	Negligible	575	
Kodangal, Mahaboobnagar	Maruti	None	None	25	Negligible	Negligible	920	ICPH 2671
	ICPH 2671	None	None	None	Negligible	Negligible	1020	
	Local	None	60	25	Negligible	Negligible	550	
Aledu, Mahaboobnagar	Lakshmi	None	None	None	Negligible	Negligible	820	PRG 158
	PRG 158	None	None	None	Negligible	Negligible	1290	
	Local	None	60	None	Negligible	Negligible	620	
Emikapally, Mahaboobnagar	ICPH 2671	None	None	None	Negligible	Negligible	1265	ICPH 2671
	LRG 41	None	None	None	Negligible	Negligible	1100	
	Local	None	None	None	Negligible	Negligible	800	
Sampally, Mahaboobnagar	Asha	None	None	None	Negligible	Negligible	750	Local
	PRG 158	None	None	None	Negligible	Negligible	820	
	Local	None	None	Negligible	Negligible	Negligible	970	
Naacharam, Mahaboobnagar	PRG 158	None	None	None	Negligible	Negligible	700	PRG 158, ICPH 2671
	ICPH 2671	None	None	None	Negligible	Negligible	720	
	Local	None	None	Negligible	Negligible	Negligible	570	
Chandravancha, Mahaboobnagar	Lakshmi	None	15	None	Negligible	Negligible	1170	Lakshmi
	LRG 41	None	25	None	Negligible	Negligible	1050	
	Local	None	30	Negligible	Negligible	Negligible	970	
Bogaram, Mahaboobnagar	Lakshmi	None	None	None	Negligible	Negligible	790	ICPH 2671
	ICPH 2671	None	None	None	Negligible	Negligible	1000	
	Local	None	None	Negligible	Negligible	Negligible	670	
Hanmanpally, Mahaboobnagar	LRG 41	None	None	None	Negligible	Negligible	990	PRG 158
	PRG 158	None	None	None	Negligible	Negligible	1290	
	Local	None	None	Negligible	Negligible	Negligible	770	

Table 9-5: Reaction of pigeonpea lines to drought, major diseases and insect pests (2009-2010)

Sr. No.	Lines	Yield (kg per ha)	Lepidopteran pod borer damage (%)	% Wilt (%)	Wilt reaction	SMD (%)	SM reaction
1	ICPL 88039	620	24.2	20.6	Susceptible	8.3	Resistant
2	ICPB 2089	840	6.9	36.7	Susceptible	25.0	Susceptible
3	ICPL 161	1180	1.9	30.0	Susceptible	60.0	Highly susceptible
4	ICPL 288	1130	8.7	44.0	Susceptible	11.1	Moderately resistant
5	ICPL 149	560	5.1	11.8	Moderately resistant	27.3	Susceptible
6	ICPL 88034	840	4.1	82.5	Highly susceptible	50.0	Susceptible
7	ICPL 90030	550	1.9	33.0	Susceptible	0.0	Resistant
8	ICPL 90034	750	15.2	17.4	Moderately resistant	0.0	Resistant
9	ICPL 90040	1400	0.3	25.4	Susceptible	0.0	Resistant
10	ICPB 2155	800	0.9	60.0	Highly susceptible	33.3	Susceptible
11	ICPB 2156	990	8.8	13.8	Moderately resistant	0.0	Resistant
12	ICPL 86022	450	6.7	49.5	Susceptible	33.3	Susceptible
13	ICPR 2438	1200	0.7	93.3	Highly susceptible	40.0	Susceptible
14	ICPL 89	990	16.9	41.3	Susceptible	-	-
15	ICPL 150	1780	7.5	16.5	Moderately resistant	0.0	Resistant
16	ICPL 90047	450	6.9	33.0	Susceptible	0.0	Resistant
17	ICPL 90048	1410	6.4	82.5	Highly susceptible	0.0	Resistant
18	ICPL 91024	2370	0.3	55.0	Highly susceptible	0.0	Resistant
19	ICPL 93101	1070	4.3	90.0	Highly susceptible	-	-
20	ICPL 90051	2380	4.3	82.5	Highly susceptible	0.0	Resistant
21	ICPL 20209	790	14.3	61.9	Highly susceptible	0.0	Resistant
22	ICPL 20211	1070	3.0	27.5	Susceptible	0.0	Resistant
23	ICPL 20216	1150	4.4	67.9	Highly susceptible	0.0	Resistant
24	ICPB 2043	2470	16.1	10.0	Resistant	0.0	Resistant
25	ICPB 2047	1750	5.7	0.0	Resistant	0.0	Resistant
26	ICPB 2048	1470	11.7	10.3	Moderately resistant	0.0	Resistant
27	ICPB 2092	2130	6.6	11.0	Moderately resistant	6.7	Resistant
28	ICPR 2671	1200	6.0	9.2	Resistant	0.0	Resistant
29	ICPL 20108	2280	5.9	12.7	Moderately resistant	18.2	Moderately resistant
30	ICPL 85063	2270	4.6	0.0	Resistant	16.7	Moderately resistant
31	ICPL 332	2250	2.0	16.5	Moderately resistant	50.0	Susceptible
32	ICPL 96053	1460	2.3	11.0	Moderately resistant	0.0	Resistant
33	ICPL 96061	1780	13.0	8.7	Resistant	14.3	Moderately resistant
34	ICPL 99044	1000	0.9	17.4	Moderately resistant	22.2	Susceptible
35	ICPL 99051	1040	8.4	17.4	Moderately resistant	29.4	Susceptible
36	ICPL 20058	1310	16.9	0.0	Resistant	41.7	Susceptible
37	ICPL 20096	1570	6.2	8.7	Resistant	5.6	Resistant
38	ICPL 20093	1500	22.2	11.8	Moderately resistant	33.3	Susceptible
39	ICPL 20101	1420	7.4	18.3	Moderately resistant	20.0	Moderately resistant
40	ICPL 20104	1050	38.0	13.8	Moderately resistant	11.1	Moderately resistant
41	ICPL 20114	1300	12.1	12.7	Moderately resistant	18.2	Moderately resistant
42	ICPL 20177	1750	9.6	20.6	Susceptible	50.0	Susceptible
43	ICPL 20201	1630	7.6	15.0	Moderately resistant	53.8	Highly susceptible
44	ICPL 20205	1580	10.0	33.0	Susceptible	15.4	Moderately resistant
45	ICP 7035	1280	11.3	35.4	Susceptible	36.4	Susceptible
46	ICP 8863	1470	4.9	27.5	Susceptible	84.6	Highly susceptible
47	ICP 8094	1030	14.7	58.2	Highly susceptible	44.4	Susceptible
48	ICP 13092	1030	7.3	29.1	Susceptible	71.4	Highly susceptible

A total of 4,307 farmers (2,474 in AP and 1,833 in Maharashtra) were trained in seed production, crop management, seed health, IPM, and post-harvest practices to ensure quality seed production. Farmers Day was also organized in Maharashtra with 351 farmers (including 21 women). During the project period, a total of 533 traders/dal mill operators in AP and Maharashtra were trained in seed storage, processing and marketing. Besides conducting training/seminars to farmers involved in seed production in AP and Maharashtra by ANGRAU and PDKV, respectively, a total of 699 extension officers, NGO staff, and private seed sector personnel were provided training in seed production, scientific storage, store grain pest management and marketing network.

Performance of pigeonpea hybrids

In AP, the performance of hybrids, especially ICPH 3359 and ICPH 2470 performed better than the check varieties (Asha and Maruti) in terms of number of pods, 100 seed weight and yield as shown in Table 9-6.

Table 9-6: Performance of pigeonpea hybrids at ARS, Tandur

Hybrid/Cultivar	Plant height (cm)	Branches/plant (no.)	Pods/plant (no.)	100 seed weight (gm)	Yield (kg per ha)
ICPH 3359	166.8	14	320	12.45	1240
ICPH 3461	142.4	15	250	11.48	1140
ICPH 2470	160.5	13	280	12.12	1210
ICPH 2671	157.3	13	270	10.95	1090
Asha (check)	135.6	16	265	11.72	1170
ICPH 3762	135.2	15	257	10.82	1080
ICPH 2673	166.0	16	280	8.93	890
ICPH 3494	158.0	19	170	11.24	1120
Maruti (check)	155.0	12	200	9.92	990
ICPH 3472	149.0	14	160	10.97	1090

The seed production manual and pamphlets are published and distributed to farmers, village level workers and extension officials at the time of field days, trainings and meetings in AP and Maharashtra. Electronic and print media was effectively utilized for dissemination of package of practices of pigeonpea production technology, field days, trainings, and exposure visit of farmers at ICRISAT in local newspapers and local radio/TV talks in AP and Maharashtra.

During the three year period of the project, a total of 6,421 farmers attended the farmers' field days/ fairs in AP and Maharashtra. A total of 4,477 small seed packets (7,800 kg) of farmer-preferred varieties were distributed to farmers.

Introduction

The importance of improving access to quality seed in pigeonpea cannot be overemphasized due to its unique traits. Pigeonpea differs from other two legumes - chickpea and groundnut - in terms of sensitivity to photoperiod (day length) and temperature, and natural out-crossing. The flowering response in pigeonpea is governed by a complex interplay of these two factors (photoperiod and temperature). It is categorized as a quantitative short-day plant and flowering initiates only when nights become longer than 14 hours. This has a potential implication for the seed producers since any delay in planting (from the normal sowing time of June- July) will result in reduced plant height and, therefore, low grain yield. Hence, the planting window available to the pigeonpea farmers is rather narrow. Other important constraint in seed production is the natural out-crossing in pigeonpea. It is one of the few legumes where natural out-crossing could be as high as 70%. This leads to rapid genetic deterioration of the seed quality in farmers' fields. In order to avoid genetic contamination, pigeonpea needs a minimum of 300 m isolation distance. This poses a serious challenge in seed production, since in the target districts during the rainy season pigeonpea is extensively cultivated by farmers.

TL II focuses on farmer-participatory varietal selection, developing new drought-tolerant varieties and establishing sustainable seed production and distribution systems primarily in South Asia, thus paving the way for the research results of TL I to be translated as breeding materials for the ultimate benefit of resource-poor farmers. The TL II project is implemented in two states in India - Andhra Pradesh and Maharashtra for pigeonpea. Cultivation of obsolete varieties and non-availability of quality seed of improved varieties are identified as major constraints leading to low productivity in pigeonpea. Low seed multiplication ratio, high volume of the seeds, storage insect pests and quick loss of seed variability are the major constraints to efficient seed production and delivery system. The seed scenario in legumes is dominated by the informal seed sector.

The major activities under this project include increased production of Breeder and Foundation Seed to enhance availability of quality seed of improved varieties in the seed chain, promote alternative seed systems to meet the seed demand, enhanced seed delivery and local seed production and storage capabilities and capacity building. This report highlights progress made during the last three years of project implementation.

Project sites

Maharashtra

Pigeonpea is grown on 1.12 million ha. The average productivity is very low (726 kg per ha). Since pigeonpea is grown mainly as an intercrop with soybean, cotton, mung bean, urd bean and others, it is necessary to identify pigeonpea varieties suitable for various ecosystems, tolerant to different stresses to sustain rain-fed cultivation.

Andhra Pradesh

The average pigeonpea productivity in the state has declined to 300-450 kg per ha despite high genetic yield potential of the varieties recommended for cultivation. Among the major constraints to pigeonpea production is *Helicoverpa armigera* (pod borer). Others include wilt (*Fusarium udum*) and sterility mosaic and lack of drought-resistant, high-yielding genotypes, and appropriate agronomic management. AP farmers obtain their seed commercially, and use farm-saved seeds for next four to five crop seasons before buying fresh seed.

Seed production and delivery systems

In India, seed system for legumes is uncertain and quite complicated. First, the economics of legumes seed production is not attractive enough for organized private seed sector due to large seed size resulting in high volume and consequently high costs in transportation and storage. On the other hand, the public seed sector which is responsible for seed production of legumes largely failed to meet their obligation because of the lack of accountability, poor quality control, need for profit, among others. Although many state governments arranged to supply seed to farmers at a subsidized cost (often this subsidized seed is not delivered to farmers in time), this has not been successful because the quantity is limited and the quality and varietal integrity are also questionable. Therefore, farmers are left at the mercy of local traders and co-farmers for their seed requirement.

Stringent requirements of seed certification agencies (minimum area required in each village for certification, minimum seed standards, requirement of accredited seed processing units and go downs) and accompanying bureaucratic hassles discourage farmers' participation in the formal seed system. In spite of the obstacles experienced during the project life, significant contributions have been realized such as the development of efficient linkages for seed production and marketing of legumes in the project sites.

The approach

With TL II project, the identified constraint has necessitated the strengthening of collaboration between the public and private sector. The seed systems objective (Objective 8) was instrumental in catalyzing up-scaling Foundation and Certified Seed, seed delivery testing models, and raising the level of farmers' awareness. The project has initiated linkages between public and private partnership to facilitate efficient seed production and efficient marketing of legumes for efficient seed diffusion. For example, the involvement of Andhra Pradesh State Seed Development Cooperation (APSSDC) and Andhra Pradesh State Seed Certifying Agency (APSSCA) in roguing, inspection and selection, and certification of farmer's seed production fields has ensured the purity and quality of chickpea, groundnut and pigeonpea seeds. In Maharashtra, the involvement of the Maharashtra State Seed Corporation, Ltd (MSSCL) and Krishi Vigyan Kendras (KVKs) has linked farmer groups of selected villages involved in seed production for efficient marketing and diffusion of certified seed in the project sites. The MSSCL function is to monitor seed production plots, which will lead to the assurance of the procurement of seed produced by the farmers. This has necessitated the selling of farmer's seed as Truthful Labeled seed to farmers.

Groups of farmers in the project sites were formed as a result of the TL II project. This enabled the marketing of own seed to co-farmers. In the project sites, government also provided seed subsidies under various schemes and packages. Diverse marketing schemes were also observed in the project area. Even though private traders and Department of Agriculture are the two key players in seed delivery of legumes in India, majority of the farmers still saved their own seed and the excess seed kernels were sold in the village during market days and co-farmers purchased them with a very minimal transaction cost involved. For traders, seed is outsourced from the local area with good quality, much cheaper, and is well perceived by local farmers since the varieties are adapted to the locality and are high yielding and sold within the area without incurring transport charges as compared to the seed procured outside the districts or state (more often, the seed is not authenticated, much expensive, no guarantee of the performance since this is new in the area, and in many instances the yield is low). The traders fixed Rs.3 to 4 ($0.08) as profit margin for a kg of seed. In other districts, where seed is accessible and moves freely, some farmers no longer keep their own seed, hence, they are dependent on the traders.

Infrastructure and equipment

Seed production facilities were upgraded at partner NARS research stations in Andhra Pradesh and Maharashtra. Installation of submersible pump, laying of PVC pipelines (2800 ft) and fencing of field were upgraded in PDKV, Akola research station to strengthen and improve irrigation facilities and protect the crop from animals for better seed production. In Andhra Pradesh, facilities for seed production were upgraded at the ANGRAU Research Station in Tandur (Table 9-7).

Table 9-7: List of equipment purchased by AP

No.	Item	Qty.	Purpose	Cost (Rs.)
1	HDPE Nylon net	205 kg	For isolation in Nucleus seed plots	67,035.00
2	Meteorological equipment	1	For recording daily weather parameters.	41,490.00
3	Winnower	1	For winnowing of harvested produce.	49,044.00
4	Water tanker	1	For providing lifesaving irrigation to Germplasm and breeding material.	227,552.00
5	Cooling incubator cum shaker	1	For maintenance of *Fusarium udum* cultures.	350,000.00
6	Horizontal and vertical electrophoresis systems.	1	For molecular variability work of the wilt pathogen.	125,000.00
Total				860,121.00

Seed storage facility (go down) with capacity of 300 MT is constructed at ARS, Tandur, Andhra Pradesh. However, in Maharashtra, farmers were not keen on having a seed storage facility due to non-availability of land to construct the facility.

Production of Breeder, Foundation, Certified and Truthfully Labeled Seed

A total of 1,794.45 MT covering 507.13 ha of different categories (Breeder, Foundation, Certified, and Truthfully Labeled Seeds) was produced by the NARS in Andhra Pradesh, Maharashtra and ICRISAT as shown in Table 9-8. However, the Certified and Truthfully Labeled Seed production program of 'farmer-preferred-varieties' in Maharashtra and Andhra Pradesh was undertaken at village level.

In Maharashtra, a total of 216.16 MT of Breeder seeds, 62.9 MT Foundation seeds, 134.1 MT of Certified Seed and 40.42 Truthfully Labeled Seed were produced. In Andhra Pradesh, 53.9MTof Breeder Seed, 7.5MT of Foundation seed, 6.54 MT of Certified Seed and 55.72 MT of TL Seed were produced while at ICRISAT, 3.21 MT of Breeder Seed was produced.

Table 9-8: Summary of various categories of see produced in AP, Maharashtra, and ICRISAT

Location	Variety	Seed Class	Area (ha)	Qty (MT)
Tandur ARS, AP	PRG-158	Breeder	2.00	3.90
Tugapur, Mahaboobnagar, AP	PRG-158	Foundation	4.00	2.80
Maktal, Ranga Reddy, AP	Asha	Foundation	6.70	4.70
Sri Venkatramireddy Kokat, AP	Asha	Breeder	43.00	30.00
		Certified	10.00	4.58
		TL	78.00	39.00
Sri B. Achutareddy, Kodangal, AP	PRG-158	Breeder	29.00	20.00
		Certified	3.00	1.96
		TL	34.00	16.72
PDKV, Akola, Maharashtra	C-11	Breeder	3.00	10.68
	ICPL-87119	Breeder	13.00	69.40
	AKT-8811	Breeder	6.00	34.12
	PKV-TARA	Breeder	20.50	101.96
PDKV, Akola, Maharashtra	BSMR 736	Foundation	1.20	1.10
	BSMR-853	Foundation	1.40	27.00
	ICP-8863	Foundation	4.33	30.60
	ICPL-87119	Foundation	2.00	4.20
Washim and Akola	ICP-8863	Certified	71.60	627.60
	BSMR 736	Certified	29.60	208.00
	BSMR 786	Certified	20.00	217.50
	Vipula	Certified	18.60	159.00
	PKV-TARA	Certified	6.80	51.00
	BDN 708	Certified	13.20	85.00
Washim and Akola	C-11	TL	14.00	7.00
	ICPL-87119	TL	8.00	4.00
	ICPL 8863	TL	12.00	6.00
	PKV-TARA	TL	17.00	8.42
	BSMR 736	TL	18.00	9.00
	BSMR 853	TL	12.00	6.00
ICRISAT	ICPL 8863	Breeder	0.20	0.13
	ICPL 87119	Breeder	5.00	3.08
Total			**507.13**	**1,794.45**

Alternative seed systems model

The concept of 'one village-one variety' was successfully promoted in Gorvha village in Akola district in Maharashtra with variety ICP 8863 (Maruti). However, this concept could not be successfully implemented in other villages (Tiptala in Akola district and Karanji, Shelgaon Omkargir and Sukanda in

Washim district) in spite of conducting promotional meetings due to the following reasons: pigeonpea intercrop with cotton was not permitted for seed certification (by the state seed certification agency), different varieties are supplied under production management packages, and farmers were reluctant in executing the Certified Seed production program.

In Andhra Pradesh, Foundation Seed production of Asha and PRG 158 varieties was successfully implemented by following 300 m isolation distance between varieties in Tandur village in Ranga Reddy district and Kodangal village in Mahaboobnagar district. Seed grower farmers were satisfied with the outcome of their produce.

Constraints and opportunities

Pigeonpea seed delivery systems, storage and marketing in both target states (Andhra Pradesh and Maharashtra) differ in constraints and opportunities. In Maharashtra, information was collected from farmers during the group discussions, meetings, training sessions, and field days. The constraints to develop an efficient seed storage, marketing and delivery system for pigeonpea were identified as lack of storage facilities, pigeonpea seed is more vulnerable to storage grain pests, lack of drying facilities (more relevant when harvesting coincides with unexpected rains), lack of processing, packaging, and transport facilities, varying and inconsistent response of farmers to new varieties, and inconsistent market price by seed industries. In Andhra Pradesh, farmers face hard time in registering and getting their fields certified. However, farmers of this state consider selling seed as TL seed to co-farmers as an opportunity in seed delivery systems.

Formal and informal seed sector linkages

To facilitate efficient seed production and marketing, PDKV-Akola established linkages with Maharashtra State Seeds Corporation Limited (MSSCL) and Krishi Vigyan Kendras (KVKs) at Karda and Durgapura. While in Andhra Pradesh, ANGRAU-Hyderabad established similar linkages with Andhra Pradesh State Seeds Development Cooperation (APSSDC) and Adarsh Rythu for efficient production and seed diffusion. The involvement of APSSDC and Andhra Pradesh State Seed Certifying Agency (APSSCA) in roguing, inspection and selection, and certification of farmers' seed production fields ensured purity and quality of pigeonpea seed. In addition, the seed village concept was instilled to grow one variety in target beneficiaries to guarantee isolation to avoid seed contamination. In Maharashtra, the involvement of MSSCL has linked farmer groups of selected villages involved in seed production for efficient marketing and diffusion of Certified Seed in Akola and Washim. The MSSCL function is to monitor seed production plots, which will lead to the assurance of the procurement of seed produced by the farmers.

Transaction costs in seed marketing

In Maharashtra, marketing of seed by individual farmer is not possible, but in Akola and Washim districts, farmers have organized themselves into groups to carry out marketing of their seed to other farmers. In both the districts, the government also provides seed subsidies under various schemes and packages. In Andhra Pradesh, seed produced at the local level has the authenticity of the source of seed, is much cheaper, is well perceived by local farmers since the varieties are adapted to the locality and are high yielding as compared to the seed procured from outside the districts or state.

Promotion and formal recognition of informal seed sector

In Maharashtra, there is a need to strengthen informal seed sector through the approach of 'seed village concept' where 'one variety-one village' strategy should be popularized because formal seed sector cannot lead to supply huge quantity of quality seeds. The seed village concept will solve the problem of the lack of quality seeds needed by the villages. However, in Andhra Pradesh, seed produced in

Mahaboobnagar and Ranga Reddy districts was offered for certification by APSSCA, whereby informal seed production was formalized.

Capacity building

Over-all, 14,114 participants including 1,740 women (farmers, traders, processors, extension workers, NGOs and private seed sector) attended meetings, seminars, trainings, and field days/fair (Table 9-9). The breakdown of participants is as follows.

Farmers training

A total of 4,307 farmers (AP – 2,474 and Maharashtra – 1,833) were trained in seed production, crop management, seed health, IPM, and post-harvest practices to enable farmers to produce quality seed. Aside from the training, Farmers' Day gatherings were also organized in Maharashtra with 351 farmers (including 21 women). This event showcased to farmers the isolation requirement in pigeonpea, identification of off-type plants in seed production blocks, off-type removal at appropriate time, irrigation scheduling, fertilizer application (including use of bio-fertilizers), harvesting, and seed storage.

Local seed traders and processor

During the 3 year project period, a total of 533 traders/dal mill operators in Andhra Pradesh and Maharashtra were trained in seed storage, processing and marketing. Around 10 dal mill operators (owners) and 76 local traders of Andhra Pradesh participated in the training course offered by ANGRAU at ARS, Tandur. In Maharashtra, training for local seed traders and dal mill owners at village level were implemented with 447 participants.

Training course

Aside from conducting trainings/seminars to farmers involved in seed production in Andhra Pradesh and Maharashtra by ANGRAU and PDKV, respectively, a total of 699 extension officers, NGO staff, and private seed sector personnel were provided training in seed production, scientific storage, stored grain pest management and marketing network. In Andhra Pradesh, a training-cum-field day program was attended by 220 participants in Kosgi village of Mahaboobnagar district and 346 participants in ARS, Tandur while in Maharashtra, 133 participants attended the training at KVK Karda, Washim.

Farmers' day/field visit/farmers' fair

During the 3-year period of the project, a total of 6421 farmers attended the farmers' field days/fairs in Andhra Pradesh and Maharashtra. In Maharashtra, 1791 farmers (including 3 women farmers) attended field days/fair organized by KVK Akola and Washim. In Andhra Pradesh, ANGRAU organized farmers' field days with an attendance of 4630 farmers (including 1150 women farmers). In both states, project staff involved in the program demonstrated ways on how to conduct roguing of off-type plants, maintenance of isolation distance, control measures of pests and diseases etc. Aside from these field days, 75 farmers were given the chance to visit demonstration fields at ICRISAT Headquarters. ICRISAT Staff guided the farmers in different projects such as watershed and pigeonpea hybrid seed production technology that the institute is showcasing.

Table 9-9: Summary of participation of farmers, extension workers, traders and private seed sector to training and exposure

Particular	Topic	State	Village	Men	Women	Total
Farmers Training	Management of Heliothis armigera, Fusarium wilt and pod fly attack in pigeonpea; seed production technology; and seed storage in pigeonpea	Andhra Pradesh	ParvathpallyBasheerabad, Ranga Reddy	385	78	463
			ChandravanchaKozgi, Mahaboobnagar	213	58	271
			ARS, Tandur	840	270	1110
			Tandur	150	70	220
			ManaGrowmore, Tandur	156	49	205
			Narayanpet, Mahaboobnagar	79	16	95
	Rabi red gram cultivation under limited irrigation; seed production technology in red gram		Pargi, Ranga Reddy	85	25	110
	Instruction about proper maintenance of seed production plots in pigeonpea; IPM and IDM management in pigeonpea; intercultural operation in pigeonpea	Maharashtra	KVK, Durgapur, Akola	886	-	886
	Insect pest management of pigeonpea; seed production technology in pigeonpea; instruction about proper maintenance of seed production plots in pigeonpea; marketing strategy		KVK, Karda, Washim	947	-	947
Farmer's Day	Isolation requirement in pigeonpea, identification of off-type plants in seed production blocks, off-type removal at appropriate time, irrigation scheduling, fertilizer application (including use of bio-fertilizers), harvesting, and seed storage		kurum, Akola	41	7	48
			Tiptala, Akola	22	3	25
			Kanzara, Akola	31	-	31
			Sirso, Akola	13	-	13
			Hirpur, Akola	118	3	121
			ShelgaonOnkargir, Washim	35	8	43
			Karanji, Washim	70	-	70
Technicians, Extension agents (including NGOs)	Seed production, processing, storage and marketing	Andhra Pradesh	ARS, Tandur	346	-	346
			ChandravanchaKosgi, Mahaboobnagar	220	-	220
		Maharashtra	KVK, Karda, Washim	133	-	133

(Table 9-9 Continued)

Particular	Topic	State	Village	Men	Women	Total
Traders/ Dal Mill operators	Seed storage, processing and marketing	Andhra Pradesh	ARS, Tandur	77	-	77
			ParvathpallyBasheerabad, Ranga Reddy	5	-	5
			ChandravanchaKosgi, Mahaboobnagar	4	-	4
	Scientific storage, store grain pest management and value addition of pigeon pea	Maharashtra	Committee Hall, Dr. PDKV, Akola	125	-	125
			KrishiVidyan Kendra, Karda	201	-	201
			KrishiVidyan Kendra, Durgapur	121	-	121
Farmer's Meeting	Pigeonpea seed production programme	Maharashtra	KVK, Karda, Washim	961	-	961
			KVK, Durgapur, Akola	767	-	767
Farmers Field Days	Farmer's Fair	Andhra Pradesh	ARS, Tandur	3400	1100	4500
			Kokat, Ranga Reddy	21	17	38
			Sangamkurdu, Ranga Reddy	19	12	31
			Nagasamunder, Ranga Reddy	16	3	19
			Kodangal, Mahaboobnagar	24	18	42
		Maharashtra	KVK, Karda, Washim	936	-	936
			KVK, Durgapur, Akola	771	-	771
			Wanoja, Washim	39	2	41
			Wadap, Washim	42	1	43
	Field exposure at ICRISAT		KVK, Durgapur, Akola	50	-	50
			KVK, Karda, Washim	25	-	25
Total				12,374	1,740	14,114

Seed distribution of farmer-preferred varieties

In support to seed multiplication of farmer seed growers, ARS-Tandur distributed a total of 1,000 samples of Asha seed (3 kg/sample) and 1,200 samples of PRG-158 seeds (2 kg/sample) in Ranga Reddy and Mahaboobnagar districts, respectively, during farmers' field days. In Maharashtra, PDKV-Akola distributed small seed packets (1 kg/sample) of various farmer-preferred varieties of pigeonpea to 1,866 farmers also during farmers' field days.

Awareness activities through print and electronic media

Pigeonpea seed production manual in local language

PDKV-Akola, in association with ICRISAT, prepared pigeonpea manuals on seed production (500 copies) and crop management (500 copies) in Marathi. ANGRAU-Tandur, likewise, published and distributed 3,500 copies of manuals on pigeonpea seed production and IPM technologies in Telugu.

Enhancing local-level awareness of released varieties

Pamphlets on Asha (ICPL 87119) variety were published in Telugu and distributed to farmers in Andhra Pradesh during farmers' fairs. In Maharashtra, farmers were encouraged to follow crop management practices through the distribution of 5,000 pamphlets on seed production practices and insect pest management in Marathi by PDKV-Akola.

Local print and electronic media

In Maharashtra, 20 articles regarding the conduct of field days, training programs, visits of the ICRISAT scientists and exposure visit of farmers to ICRISAT, Hyderabad and targeted villages were published in local newspapers. These were also covered by three local radio stations and one local TV station for wider circulation of the project activities and gains among the farmers. In Andhra Pradesh, five local TV stations telecast information on pigeonpea varieties and crop management technologies.

Enhancing Pigeonpea Productivity and Production in Eastern and Southern Africa

NVPRG Rao, Said N Silim, Franklin Simtowe (ICRISAT-Nairobi); Moses Siambi, Emmanuel S Monyo (ICRISAT-Malawi); Stephen Lyimo, Rose Ubwe, Frank Mbando (SARI-Arusha, Tanzania); Joseph Mligo (ARI-Ilonga, Tanzania); Geoffrey AD Kananji, Francis W. Maideni (DARS-Lilongwe, Malawi)

Summary

In ESA, Tanzanian and Malawian NARS implemented the pigeonpea research and development activities in close partnership with ICRISAT-Nairobi, farmers, NGOs, CBOs and all other major stakeholders. The project was implemented in Babati (Manyara Region), Karatu (Arusha Region) and Kilosa (Morogoro Region) districts of Tanzania. In Malawi, on-farm research and promotion activities were carried out in 14 districts spanning from Southern (Balaka, Blantyre, Machinga, Mwanza, Zomba), Central (Kasungu, Mchinji, Ntcheu, Ntchisi, Salima), and Northern (Chitipa, Karonga, Mzimba, Rumphi) regions during the Phase 1.

During this phase, a major success was on fast tracking the release of two medium duration pigeonpea varieties (ICEAP 00557 and ICEAP 01514/15) in Malawi. The new releases in Malawi were a landmark because there had been no released medium duration pigeonpea varieties in the past. With this, the number of pigeonpea varieties released in Malawi rose to six (2 short, 2 medium and 2 long duration group). In Tanzania, 2 medium (ICEAP 00554, and ICEAP 00557) and 2 long duration varieties (ICEAP 00053 and ICEAP 00932) are being evaluated under National Performance Trials (NPT) and are in final stages of the release process.

In ESA, there is very limited awareness of improved pigeonpea varieties due to a consistent failure of the public sector to supply good quality source seed. The private sector has shown little interest in seed production and most often seed is produced in high potential areas or areas with infrastructure for storage and processing far away from its area of utilization, leading to high seed costs. To overcome these constraints, investments have been made in breeder and foundation seed production, and proceeds from seed sales used to re-capitalize seed revolving funds to support subsequent seed production cycles. Foundation seed has been marketed to private companies and NGOs for further seed production and dissemination. During 2007-10, a total of 21.18 MT Breeder, and 440.2 MT Foundation and Certified seed of ICEAP 00040 (Mali in Tanzania, Kachangu in Malawi), ICEAP 00068 (Tumia), ICPL 87091(Komboa), and ICP 9145 was produced at research stations and farmer fields. In addition to this in Tanzania, 21.0 MT and 1.7 MT of seed distributed to farmers and farmers' groups, respectively, to feed into the informal seed systems.

A total of 146 Farmers' Participatory Varietal Selection (PVS) trials that included 8-9 pre-released/released varieties along with a farmer's variety as a check were conducted in Tanzania (60) and Malawi (86). A total of 3644 farmers took part in the PVS trials from Tanzania (1989) and Malawi (1655). In addition, 541 field demonstrations were organized in Tanzania (455) and Malawi (86) to quickly disseminate promising varieties and production technologies. During the PVS farmers came up with a number of preferred traits, which facilitated in short-listing of varieties for fast track varietal release. In total, 29 field days were conducted in target locations of Tanzania (6) and Malawi (23) with the participation of 2909 farmers in the two countries. During the field days farmers were asked to select preferred varieties along with preference criteria.

Training programs on pigeonpea seed production, seed storage, and utilization technologies and value chain were organized to improve the knowledge base of 6200 farmers(3700-Tanzania, 1300-Malawi), 72 extension personnel (50- Malawi, 22-Tanzania) and eight farmer groups. Information bulletin was published on improved pigeonpea technologies and seed production in Malawi (both in English and

Chichewa) and Tanzania (Swahili). One participant each from Malawi and Tanzania made a visit to ICRISAT-Patancheru and familiarized with pigeonpea breeding, seed production, crop management, including hybrid pigeonpea. Under degree training, Ms. Mayomba Maryanna Maryange from Tanzania is working on pigeonpea improvement for her PhD.

Introduction

In ESA, pigeonpea is widely grown in Tanzania, Malawi, Kenya, Uganda and Mozambique, and to a little extent in Burundi under maize-mixed (66% area) and root-crop-sorghum/millet mixed (29%). Area and production during the last decade increased by 45.3% and 50.3%, respectively; however, productivity gains are just 3.2% only (Table 10-1).

In Tanzania, the area and production are increased almost 150% over the period of decade. The productivity changes are very minimal and erratic at a national level, however the average productivity reached almost 1 MT per ha in Northern Tanzania, wherein adoption of high yielding varieties are at higher level. In Tanzania, over 50% of the farmers in Babati district adopted new varieties (ICEAP 00040 – Mali and ICEAP 00053) and production area expanded beyond the traditional Babati district to reach the neighboring districts of Karatu, Kondoa and Mbulu. There is expansion now to new districts of Arumeru, Hai and Rombo in northern Tanzania.

In Malawi, area, production and productivity increased at the rate of 29.1%, 88% and 46%, respectively, during the last decade. The release of a new set of medium duration varieties in Malawi (ICEAP 00557 and ICEAP 01514/15) that are suitable to grow in Southern, Central and Northern regions of Malawi opened up avenues for area expansion.

Table 10-1: Area, production and productivity trends

Year	Area (000 Ha)	Production (000 MT)	Productivity (Kg per Ha)
ESA [1]			
2001-03	515.9	356.6	692
2004-06	733.0	448.4	611
2007	768.9	541.9	705
2008	809.5	522.2	645
2009	750.9	535.9	714
Tanzania[2]			
2001-03	65.9	49.4	750
2004-06	155.6	112.2	719
2007	164.2	123.2	750
2008	165.0	132.0	800
2009	168.0	126.0	750
Malawi[1]			
2001-03	141.0	109.4	776
2004-06	148.2	96.0	651
2007	161.5	159.4	987
2008	167.8	149.9	893
2009	182.0	206.0	1132

[1]= data source FAO and [2]= FAO data supplemented with data from Statistics Unit-Ministry of Agriculture, Food Security and Cooperatives

Locations and partners

During the phase project activities were implemented in Tanzania and Malawi. A detailed account of same is presented in Tables 10-2a and 10-2b. Phase 2 also involves Uganda with major focus on Kitgum and Lira districts of Northern zone.

Table 10-2a: Target locations and partners in Tanzania

Country	NARS Partner	Zone	Region	District	Scientists
Tanzania	SARI- Arusha; IARI- Kilosa	Northern	Manyara	Babati	Stephen Lyimo, Joseph Mligo, Rose Ubwe, Frank Mbando
			Arusha	Karatu	
		Eastern	Morogoro	Kilosa	

Table 10-2b: Target locations and partners in Malawi

Country	NARS Partner	Region	District	Extension Planning Area(EPA)	Scientists
Malawi	DARS-Lilongwe	Southern	Mwanza	Mwanza, Thambani	Kananji GAD, Nyirenda E, Maideni F W
			Balaka	Mpilisi, Rivi-Rivi	
			Blantyre	Lunzu, Chileka	
			Zomba	Dzaone	
			Machinga	Nyambi	
		Central	Mchinji	Chiosya, Mikundi	
			Kasungu	Kaluluma, Chulu	
			Ntchisi	Chikwatula	
			Salima	Chipopka, Chinguluwe	
			Ntcheu	Manjawira	
		Northern	Mzimba	Manyamula, Euthini, Mpherembe, Bwengu	
			Karonga	Lupembe, Mpata	
			Rumphi	Bolero	
			Chitipa	Lufita	

Socio-Economics/Targeting

Baseline data collected during Phase 1 in Malawi and Tanzania provided very valuable information on several aspects of pigeonpea value-chain on production, seed systems and marketing. Summarized accounts of are presented below.

Pigeonpea producing areas and production systems

The bulk of pigeonpea production is concentrated in the southern region of Malawi. The Blantyre and Machinga ADDs accounted for about 90% of the total pigeonpea area. Pigeonpea is widely grown as an intercrop with maize in southern Malawi, but it is mainly grown as a boundary marker in northern Malawi. In Tanzania, the major pigeonpea growing areas are Lindi and Mtwara regions in the southern zone; Kilimanjaro, Arusha, and Manyara regions in the northern zone; and Shinyanga Region in the Lake Zone. It is also grown along the coast, Dar es Salaam, Tanga and in Morogoro regions in the Eastern Zone, where it is used mainly as vegetable.

Cropping patterns

In Malawi, over 90% of the households planted maize in the 2006/2007. Groundnut is the second most frequently cultivated crop (55%), while pigeonpea comes third and it is cultivated by 40% of the households in the sample. When it comes to the share of crop area, that 54% of the cultivated land is allocated to maize, while groundnuts and pigeonpea are allocated 17% and 15% of the total cultivated land, respectively. The average area cultivated for pigeonpea is 0.3 ha.

In Tanzania, pigeonpea is the third most important legume, after common bean and groundnut. Pigeonpea is grown by 88% of the farmers in the target areas and the average planted area is about1.36 ha, mainly through intercropping with maize.

Available technologies

Although improved pigeonpea varieties were released as early as 1987, their dissemination and adoption by smallholder farmers remain low. Simtowe et al. (2009) reported that only 10% of the sampled farmers grew improved pigeonpea varieties in 2007, although 40% of them could potentially adopt improved varieties of pigeonpea if they were exposed to the varieties and had access to seed. The main constraint to the adoption of improved pigeonpea varieties has been the lack of access by farmers to sufficient quantity of good quality seed. The analysis on technology awareness indicated that about 74% of the households are aware of at least one pigeonpea variety. The awareness rate for improved pigeonpea varieties (ICP 9145 [released in 1987] and ICEAP 00040) is much lower. Of the two improved varieties, ICEAP 00040 is the most widely known by 20% of the farmers while ICP 9145 is only known by 8% of the farmers. Aside from the lack of awareness for some of the legume varieties, seed is a major constraint to adoption. Among pigeonpea varieties, Mthawajuni and ICEAP 00040 are the preferred varieties with overall rankings of 4.3 and 4.1, respectively (on a 1 to 5 scale: 1= poor and 5= excellent). The findings further indicate that most highly preferred varieties are liked for the three key traits they exhibit: high yield, early maturity and short cooking time. Interestingly, Mthawajuni, considered as a local variety, is preferred for its high yield, as well as early maturity, and shorter cooking time.

Three varieties were released in Tanzania, namely Mali (ICEAP 00040, long duration), Tumia (ICEAP 00068) and Komboa (ICPL 87091) in long, medium and short duration groups, respectively.

Productivity

In Malawi, the average grain yield of pigeonpea for the period 2001-2006 was about 700 kg per ha. This is about half of the potential yield on station of about 1300 kg per ha for improved varieties. The observed yield gap suggests that there is scope for increasing pigeonpea productivity once farmers adopt improved varieties and if they follow recommended management practices. The low adoption of available new varieties is mainly attributed to the underdeveloped and inadequate seed systems, shortage of quality seed and lack of timely delivery, lack of awareness, and insufficient access to credit to farmers, among others. The improved varieties yielded about 1297 kg per ha in Tanzania while locals averaged around 1097 kg per ha. The net income (to land and family labor) was MK 9340 per ha in Malawi and Tsh 388,129 per ha in Tanzania. The net income from improved varieties was about 15-18% higher than local varieties.

Utilization

Available estimates indicate that 65% of the pigeonpea produced is consumed on-farm, 25% is exported, while 10% is traded on the domestic markets. However, the consumption rate of 35% reported for Tanzania attributes the low on-farm consumption rates in Tanzania to the high integration of producers in the market channels.

Marketing systems

The actors in Malawi's pigeonpea market include small- and large-scale producers, intermediate buyers, farmers' associations, processors and consumers. The most prevalent grain legume marketing system involves individual farmers selling small quantities to intermediate buyers. Other prevalent marketing systems involve (i) individual farmers selling pigeonpea to local markets, (ii) farmers organizing themselves into groups which pool together their products, identify buyers (often a company) and sell at negotiated prices, and (iii) farmers selling their grain legumes to NGOs. There are several categories of buyers which include intermediate buyers, processing and packaging companies, and other consumers of grain legumes. For example, Muli Brothers Ltd, a Malawian local company, is one of the companies involved in the marketing of pigeonpea. Malawi has the largest concentration of processing companies for pigeonpea. About 40% of the pigeonpea exports to India are processed, while 60% is exported in the form of raw pigeonpea grain. There are more than twelve pigeonpea millers in Malawi with a total milling capacity of 20,000 MT of dhal per annum. The companies processing pigeonpea include Transglobe Produce Exports, Rab Processors and Bharat Trading Company. A processing plant was installed in Blantyre by Export Trading Company Ltd in April 2009.

Threats and opportunities

Demand for pigeonpea continues to rise; however, there is increasing pressure on African farmers to benefit from these markets due to intense competition for export markets (mainly India) from Myanmar and other emerging producers, as well as the surging demand for other substitutes (e.g. yellow pea produced mainly in Canada and France). The findings suggest the need for faster productivity enhancement, strengthening seed delivery systems to reach farmers who continue to rely on low-yielding and disease-susceptible local varieties, and development of existing value chains and alternative pigeonpea export markets. Lo Monaco further reports that seasonal pigeonpea price variations in India offer a window of hope for African countries to export pigeonpea to India when prices are high. Lo Monaco further reports that pigeonpea prices in India are lowest in March-April, and begin to rise from July. The prices are reported to be at the peak around November-December. In Malawi pigeonpea is harvested between July and August which coincides with a period of high prices in India. Malawi could, therefore, take advantage of this window to improve its pigeonpea competitiveness. The same is the case with Tanzania; harvest season of long duration varieties in northern Tanzania coincides with lean pigeonpea availability in India.

Fast-Tracking, Development, and Release of Varieties

Variety development

Varietal development and evaluation in the two target counties centered on target ecologies and farmer- and market-preferred grain traits. Keeping the existing biotic and/or abiotic constraints that affect productivity in the smallholder farming systems in the region, three preliminary test sites Kabete (high altitude cool environment), Kampi Ya Mawe (purely rain fed) and Kiboko (hot spot for *Fusarium* wilt) are integral parts of pigeonpea breeding program at ICRISAT in Kenya. ICRISAT-Nairobi with large collection of regional germplasm and on-going breeding program on three maturity groups (short, medium and long) evaluated 325 new genotypes(short-72, medium-71, long-182) at the three test locations mentioned above. Simultaneously, best lines in each maturity group based on agro-ecologies in target countries supplied and evaluated. In Tanzania, Selian and Ilonga, respectively representing Northern Zone (more emphasis on long duration) and Eastern Zone (more emphasis on medium duration) evaluated 45 medium and 85 long duration genotypes. Ilonga center also evaluated 36 short duration genotypes. Similarly, in Malawi, 45 medium and 69 long duration genotypes were evaluated at central (more focus on medium) and southern regions.

Through multi-locational and multi-year evaluations, ICEAP 00673, ICEAP 01170, ICEAP 01179, ICEAP 01499/7, ICEAP 01169, ICEAP 01147, and 00671/2, possessing drought tolerance coupled with high yield were carried out under medium maturity group. In long duration-late group that are suitable for Northern Tanzania, ICEAP 01423 and ICEAP 01202 outperformed other varieties/lines. Under the long duration- normal group, ICEAP 01484, ICEAP 01511, ICEAP 01528, ICEAP 01489 and ICEAP 01485 were superior; these are suitable to Southern Malawi and mid altitude areas.

Fusarium wilt is one of the major diseases, constraining pigeonpea productivity in ESA. The virulence pattern existing in ESA is entirely different from that of Asia. Further, it is believed that landraces in ESA co-evolved with virulent wilt races of ESA. Hence, the landraces collected from Tanzania, Mozambique, Kenya and Malawi were evaluated in wilt sick plots at Kiboko over the years. Wilt progression data indicated that Acc 128, 125, 130, 74 and 135 (Tanzania), Acc 72 (Mozambique) and Mthwajuni (Malawi) showed less wilt incidence and high yield; accordingly, they are more potential donors in wilt resistance breeding. Multilocational evaluation of seven genotypes at Makoka, Chitala, Bvumbwe and Chitedze in Malawi showed that ICEAP 00926 and ICEAP 00576-1 as high yielding-cum wilt resistant. Superior long and medium duration genotypes in yield evaluation trials were also screened for *Fusarium* wilt tolerance under wilt sick plot in Kenya and found that ICEAP 01203, ICEAP 01197, ICEAP 01179, ICEAP 01160 as wilt resistant genotypes and they were descendents of ICPL 87091 x 1CEAP 00020 / ICEAP 00040. Screening of one long and one medium duration trials in Tanzania and Malawi at endemic areas of wilt indicated that ICEAP 01392, ICEAP 00933, ICEAP 00040, ICEAP 00926 and ICEAP 01499/7 as wilt resistant.

Varietal release

In ESA target countries, a total of 9 varieties have been released during the project period as per the details below (Table 10-3).

Table 10-3: List of pigeonpea varieties released in ESA

Variety	Popular Name	Release year	Country	Average on-farm yield (kg per ha)	Yield advantage over check (%)
ICEAP 00850	-	2009	Kenya	1457	12
ICEAP 00936	-	2009	Kenya	1380	10
ICEAP 00557	Mwaiwathu Alimi	2009	Malawi	1192	28
ICEAP 01514/15	-	2011	Malawi	1430	59
ICEAP 00040	-	2011	Mozambique	1680	34
ICEAP 00020	-	2011	Mozambique	1630	30
ICEAP 00554	-	2011	Mozambique	1870	50
ICEAP 00557	-	2011	Mozambique	1960	56

Identification of farmer- and market-preferred varieties

A total of 146 Farmers' Participatory Varietal Selection (PVS) trials that included 8-9 pre-released/released varieties along with a farmer's variety as a check were conducted in Tanzania (60) and Malawi (86). A total of 3644 farmers took part in the PVS trials from Tanzania (1989) and Malawi (1655). In addition, 541 field demonstrations were organized in Tanzania (455) and Malawi (86) to quickly disseminate promising varieties and production technologies (Table 10-4).

During the PVS, farmers looked for early maturity, high yield potential, large cream-coloured seed, resistance to *Fusarium* wilt, terminal drought tolerance, and vegetable types with green pods for local niche markets. It should be also noted that men were more interested in market traits as grain whereas women showed preference for consumption as green pods. The list of varieties preferred by farmers (Table 10-5) paved the way for fast-tracking in release and notification (ICEAP 00557 and ICEAP01514/15 in Malawi). Till date farmers knew only long and short duration varieties released so far; after learning about medium duration varieties through PVS, farmers in all the pigeonpea growing areas such as Southern (due to unreliable *chiperoni* rains), Central (early maturing varieties to meet livestock grazing demand after harvest of maize) and Northern regions (due to short growing season) they came to know about and use medium duration varieties. Similar preferences for medium duration varieties were also noticed in a few pockets of Northern Zone, which experiences early cessation of rains.

Table 10-4: Pre-release or released varieties used in PVS trials (2008-10 crop seasons)

Country	Variety name		
	Medium duration	Long duration	Check
Tanzania	ICEAP 00554, ICEAP 00557	ICEAP 00040, ICEAP 00053, ICEAP 00576-1, ICEAP 00932, ICEAP 00933, ICEAP 00936	Local variety
Malawi	ICEAP 01514/15, ICEAP 00557, ICEAP 01480/2, ICEAP 01162/21, ICEAP 01167/11	ICEAP 00040, ICEAP 00020, ICEAP 00932, ICEAP 00576-1	Mthwajuni

Table 10-5: Varieties preferred by farmers

Country	**Variety**	
	Medium duration	Long duration
Tanzania	ICEAP 00554, ICEAP 00557	ICEAP 00040 (Mali), ICEAP 00053, ICEAP 00932, ICEAP 00936
Malawi	ICEAP 01514/15, ICEAP 00557, ICEAP 01167/11	ICEAP 00932, ICEAP 00576-1

Seed Production and Delivery Systems

In Eastern and Southern Africa, lack of awareness and limited or no access to quality seed attributed by consistent failure of public sector in supplying good quality breeder/foundation seed in desired quantities, private sector has shown little interest in investing pigeonpea seed production and marketing, most often seed production areas are far away from its area of utilization because of isolation requirements and availability of infrastructure for storage and processing leading to high transaction seed costs. Through this project selective investments have been made to overcome these constraints in breeder and foundation seed production, and seed sale proceeds used to create seed revolving funds especially in Malawi (ICRISAT model) for future use.

Private seed companies and NGOs took the lead in acquiring Foundation Seed for further seed increase and dissemination. Most of the farmers rely on self-saved seed and access to seed of improved varieties either through informal networks. The baseline survey also points out existence of two seed supply systems, namely informal, which are usually non-market based and the quasi-formal, mainly market-based seed supply systems. The informal seed supply sources included own saved seed; gifts from family and friends; farmer-to-farmer seed exchanges and others. The importance of quasi-formal seems to increase with formal release of new farmer- and market-preferred varieties, which helps in augmentation of seed demand and seed markets for superior varieties.

During the past four years (2007-10) a total of 21.18 MT Breeder Seed and 440.2 MT Foundation and Certified seed of farmer-preferred improved pigeonpea varieties was produced at research stations and farmers' fields (Tables 10-6 & 10-7). In Tanzania, farmers and farmer groups were engaged in seed production. Twenty one MT of quality seed of four varieties (12.2 MT Mali, 7.6 MT ICEAP 00053, 0.4 MT ICEAP 00932 and 0.8 MT ICEAP 00554) was distributed to farmers during 2007-09; this covered 2653 ha in farmers' fields in seed production and subsequent seed sharing among the farming community in the project areas. Similarly, 1.7 MT of quality seed of four varieties was distributed to 15 farmers' groups and facilitated the production of 11.0 MT of quality seed (Tables 9 & 10). RECODA (Research, Community and Organizational Development Associates) in Endabash Ward in Karatu District, World Vision through Gorowa ADP (Area Development Program) in Duru and Riroda wards in Babati District and CRS (Catholic Relief Services) through Mbulu Catholic Diocese supported smallholder farmers in North and Central Karatu by buying pigeon pea seed from farmers and other sources and distributing to smallholder farmers.

Table 10-6: Various classes of quality seed produced in ESA (MT)

Country	No. of varieties	Breeder	Foundation	Certified	Total
Tanzania	3	10.80	54.00	205.50	270.30
Malawi	3	2.40	37.70	143.00	183.10
ICRISAT-Nairobi	9	7.98	-	-	-
Total	**15**	**21.18**	**91.70**	**348.50**	**461.38**

Table 10-7: Breeder Seed of different varieties produced at ICRISAT-Nairobi (MT)

Variety	Tolerance & Special Trait(s)	Breeder seed
ICEAP 00040	LD[1] and wilt tolerant variety released in Kenya(KARI Mbaazi-2, Tanzania (Mali), Malawi (Kachangu) and Mozambique	2.14
ICEAP 00557	MD variety released in Malawi(Mwaiwathu Alimi) and Mozambique; and final stages of release process in Tanzania and Kenya	1.16
ICEAP 00554	MD variety released in Mozambique and under NPT in Kenya, Tanzania and Malawi	0.93
ICPL 87091	SD variety released in Kenya, Mozambique, Tanzania and Uganda	0.92
ICEAP 00053	LD variety under NPT in Tanzania	0.85
ICEAP 00932	LD variety released in Kenya and under NPT in Tanzania	0.64
ICEAP 00936	LD variety under PVS in Tanzania	0.6
ICEAP 00020	LD variety released in Mozambique	0.38
ICEAP 00850	MD variety released in Kenya	0.36
Total		**7.98**

Table 10-8: Different classes of pigeonpea seed produced (MT) in Tanzania and Malawi (2008-2010 crop seasons)

Variety	Breeder	Foundation	Certified
Tanzania			
Mali(ICEAP 00040)	3.5	54.0	178.5
Tumia (ICEAP 00068)	2.8		11.5
Komboa (ICPL 87091)	4.5		15.5
Malawi			
Sauma (ICP 9145)	1.2	-	108.0
Kachangu (ICEAP 00040)	1.2	63.0	
Mwaiwathu Alimi (ICEAP 00557)	9.7		-

Table 10-9: Amounts (MT) Foundation Seed of four pigeonpea varieties distributed to farmers in Tanzania

Year	Variety				Total	Area covered (ha)
	Mali	ICEAP 00053	ICEAP 00932	ICEAP 00554		
2008	5.0	3.6	-	-	8.6	995
2009	3.0	2.0	-	-	5.0	667
2010	4.2	2.0	0.4	0.8	7.4	991
Total	**12.2**	**7.6**	**0.4**	**0.8**	**21.0**	**2,653**

Table 10-10: Seed distributed to farmers' groups for seed production in Tanzania (MT)

Year	Variety				Total seed distributed	Seed Produced	No. farmer groups participated
	Mali	ICEAP 00053	ICEAP 00932	ICEAP 00554			
2008	0.7	0.3	-	-	1.0	3.0	7
2009	0.38	0.28	0.02	0.02	0.7	5.0	8
Total	**1.08**	**0.58**	**0.02**	**0.02**	**1.7**	**11.0**	**15**

[1] LD, MD and SD refer to long-, medium- and short-duration, respectively

Seed Production and Delivery Strategies

Various seed production and delivery strategies have been tried for various seed classes. The most effective ones are summarized in Table 10-11.

Table 10-11: Effective seed systems identified for pigeonpea production in Tanzania and Malawi

Seed class	Malawi	Tanzania
Breeder Seed	Research centers	Research centres
Foundation Seed	Revolving seed scheme, private sector, NGOs	Farmer-Field-Schools, private sector, NGOs
Certified Seed	Specialized smallholder farmers	Farm organizations
Quality Declared Seed	Farmers, farm organizations	Farmers, farm organizations

Two major non-governmental organizations have been identified in Tanzania (Dutch Connection and KIMAS) and three in Malawi (PLAN Malawi, CARE Malawi and MVP) which are actively involved in legume seed production and distribution. Two private seed companies in Malawi (Funwe Seeds and Seed Co) and four in Tanzania (ASA, Zenobia, Krishna, Miombo Estate) venture into commercial seed production. Three pro-poor seed delivery seed systems such as seed revolving fund facility, community seed banks, and farmer field schools were tested.

Community-based seed production and marketing systems like quality declared seed (QDS), which is tested in Tanzania for dissemination of truthfully labeled seed of high quality could be one strategy for easing the seed shortage problem, especially for open-pollinated cereals or self-pollinated legumes like pigeonpea. The private sector lacks the incentive to participate in the enhanced delivery of seed of these crops as the size of the market is small and farmers are able to use recycled seed for 3-5 years. Strengthening the on-going farmer based seed production program and revolving seed scheme by improving farmers' skills in seed multiplication can assist in increasing the supply of seed for improved varieties both within communities and to the formal seed system. The revolving seed scheme where target farmers are often organized into groups or cooperatives access a certain amount of seed of improved varieties from a supplier (e.g., NGO or Ministry of Agriculture) and return at least the same amount of seed in-kind, is an important mechanism in the absence of adequate supply of improved seed to reach all farmers. The development of a commercial seed sector should go in parallel with the development of a commercial grain market, which is poorly developed in most parts of the countries. In the absence of a commercial grain market, it is unreasonable to expect a commercial seed market to emerge. Agro-processing and other forms of value adding such as packaging would significantly increase the profitability of pigeonpea production.

Capacity building

Training of farmers

In Tanzania, training sessions were organized on pigeonpea agronomy with participation of eight farmer groups involved in seed production.

Field days, farmers' fairs

In Tanzania, four farmers' field days with participation of 1554 farmers and additional 6200 farmers were trained on various pigeonpea technologies including quality seed production and processing and generated greater interest about new varieties among various stakeholders. Twenty five farmer's field days were conducted in Central and Southern Malawi with participation of 1355 farmers also generated greater awareness on quality seed. The field day events in Southern Malawi were covered on Malawi television (TVM), Malawi Broadcasting Cooperation (MBC) Zodiac Broadcasting Station (ZBS) and The Nation newspaper.

Awareness activities

Farmers' field days, bulletins, news media (both electronic/digital and print) coverage, farmers' assessments, processing and utilization were used to disseminate the technologies. Information bulletin on various aspects of pigeonpea production, insect pest management, post harvest processing and utilization in Kiswahili "*Kilimo Bora Cha Mbaazi*" produced and distributed to farmers and other stakeholders during visits to Institute, farmers' field days, farmers assessments, *nane nane* Agricultural shows in Tanzania. The annual *nane nane* (meaning the eighth day of eighth month in Swahili) agricultural and livestock products and services show organized by the Tanzania Agricultural Society (TASO) coincides with farmers' day, a national holiday in Tanzania, on 8 August. A manual for pigeonpea production in Malawi was published in English and Chichewa. Flyers describing pigeonpea printed in Chichewa and Swahili and distributed to farmers in project sites (more than 5,000 flyers).

Training of extension personnel

Seventy two MOA and NGO staff members were trained as master trainers on pigeonpea production technology, seed storage, business skills, and value chain (Table 10-12).

Table 10-12: Details of participation in production technology training

Country	Training focus	Participants
Tanzania	Techniques for scaling up and scaling out of improved pigeon peas varieties safe storage, PVS approach and facilitation, basic data collection skills	22 extension officers from Babati and Karatu Districts trained during planting of PVS and demos
	ToT training on Business skills and Value Chain	14 stakeholders from research, extension, agro-dealers, NGOs, Agricultural Sector Marketing Programs, farmers' organizations
	A ToT on legumes seed production and marketing	15 people including 5 women, representing researchers, research technicians, seed producers, extension specialists, agro-dealers and NGOs
Malawi	Pigeonpea on-farm trial conduction, crop management which includes quality seed production.	50 frontline extension staff which includes 43 men and 7 women

Training of scientists

Stephen Lyimo from Selian Agricultural Research Institute (Arusha) and Geoffrey AD Kananji from Chitedze Agricultural Research Station-Lilongwe visited ICRISAT. Stephen Lyimo made a visit during Dec 2009 to collaborating institutions and farmers in India to familiarize with legume management technologies in general and pigeonpea and chickpea in particular including seed production, processing and utilization, and marketing. Similarly, Dr. Geoffrey Kananji visited ICRISAT Headquarters in January 2010 for training in pigeonpea breeding and crop management (Table 10-13).

Table 10-13: Details of training participants from ESA

Name	Country	Affiliation	Year
Stephen Lyimo	Tanzania	SARI-Arusha	Dec 2009
Kananji GAD	Malawi	CARS-Lilongwe	Jan 2010

Degree students

One PhD student, Maryanna Maryanga Mayomba from Tanzania registered with Sokoine University working on pigeonpea for her PhD.

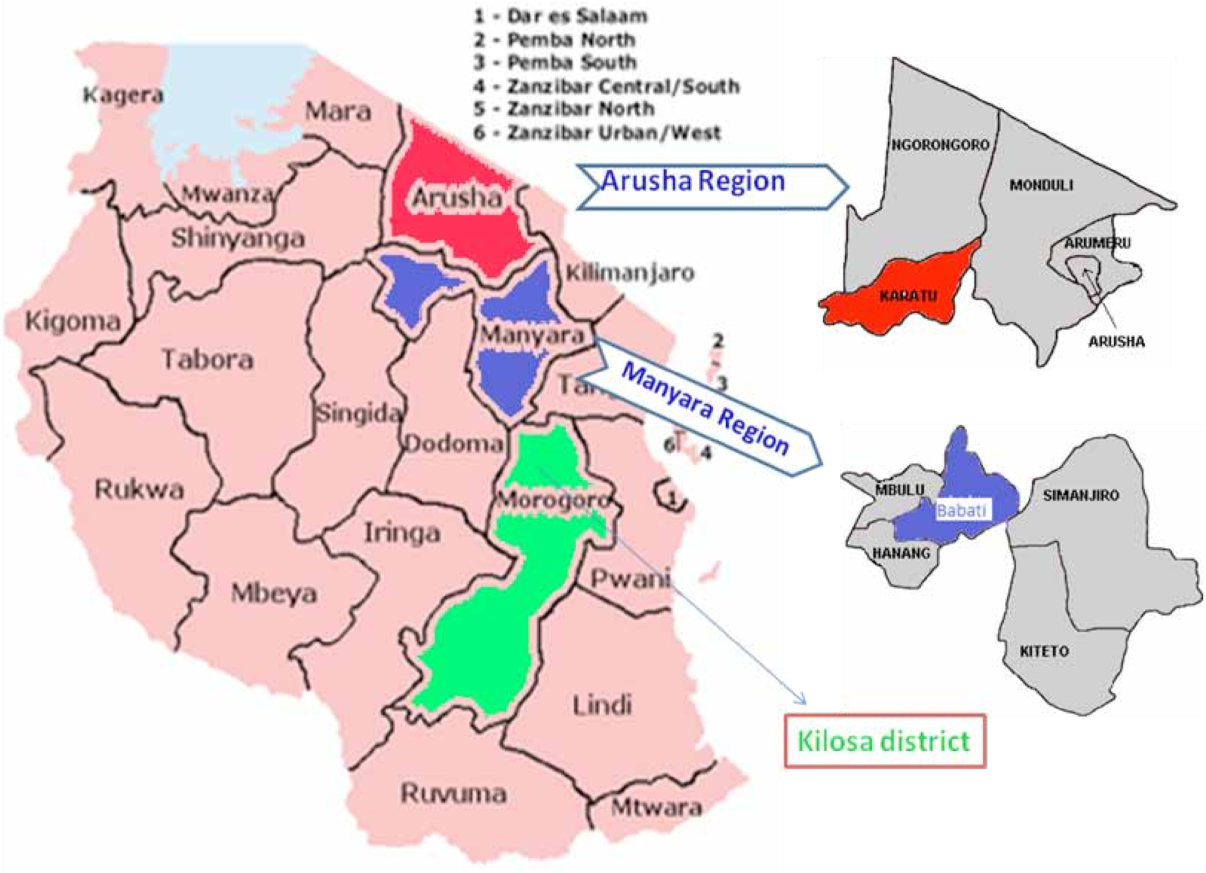
Lessons learned

- The individual farmers are often reluctant to become seed growers due to lack of capabilities for seed processing and storage and difficulties in marketing. Community Seed Producer Associations may be promoted which will have better access to seed processing and storage facilities and marketing;
- Pigeonpea is a often cross pollinated crop because of insect(honey bees) pollination and finding appropriate isolation distance (500 m) for seed production has proved to be most difficult task. This situation further aggravated by stray and self sown pigeonpea plants, pigeonpea growing in backyards, homesteads, and social factors;
- Seasonal fluctuations in the preference for pigeonpea crop among the farmers and there by inconsistent seed demand over years;
- Farmers' awareness on improved varieties and seed availability of improved varieties are the key factors in spread of improved pigeonpea varieties;
- Conduct of PVS, field days and seed fairs are very effective in awareness creation among farmers about new varieties and generate sustained seed demand;
- Lack of proper cleaning, grading and storage facilities hampers seed production by individual farmers;
- The farmers were very keen to take up seed production provided arrangement was made for assured procurement of seed;
- Sustainable seed production by smallholders stands a better chance of success if complimented by functional seed and product markets;
- Project interventions should focus on pro-poor seed production and delivery systems that have a better chance of surviving beyond the lifespan of the project;
- Need for faster varietal testing and release systems in ESA to enhance the spectrum of varieties available to farmers;
- Business-oriented small holder farmers perform better in seed production, storage, and dissemination than food security-oriented farmers, hence these group of farmers should be involved in seed systems;
- Limited number of research and seed technicians available in ESA also hampers progress of seed dissemination;
- Efficient linkages between formal and informal seed systems are critical success factors;
- Seed production under assured growing conditions to harvest assured seed; and
- Knowledge empowerment of progressive farmers so that they can take up seed production.

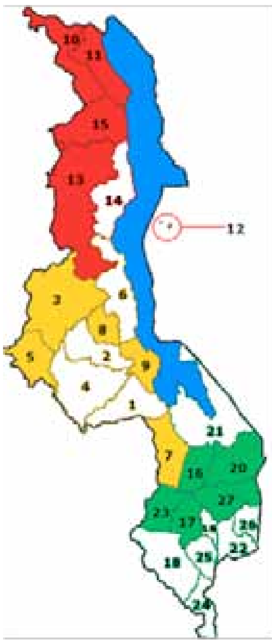
Vision for second phase

- The activities will be expanded to new districts within the existing zones/regions in Tanzania and Malawi. In Uganda, as a new country in phase 2 project activities will be carried out in Kitgum and Lira districts of Northern Uganda;
- Establishing functional legume value-chains to stimulate seed demand;
- Seed production manuals published, awareness created through PVS, new varietal releases – fosters better seed systems in second phase;
- Strengthening linkages between researchers, seed producers, agro-dealers, private large scale entrepreneurs;

Annex 10-1: Target locations for pigeonpea in Tanzania



Annex 10-2: Target locations for pigeonpea in Malawi



Region	District number in Map	District Name
Northern	10	Chitipa
	11	Karonga
	13	Mzimba
	15	Rumphi
Central	3	Kasungu
	5	Mchinji
	7	Ntcheu
	8	Ntchisi
	9	Salima
Southern	16	Balaka
	17	Blantyre
	20	Machinga
	23	Mwanza
	27	Zomba

Enhancing Soybean Productivity and Production in Drought-Prone Areas of Sub-Saharan Africa

Hailu Tefera (IITA-Malawi), Bernard Vanlauwe (CIAT/TSBF-Kenya), Stephen Boahen (IITA-Mozambique), Arega Alene (IITA-Malawi), Geoffrey Kananji (DARS-Malawi), Mohammad Ishaq (NCRI-Nigeria), Ranajit Bandyopadhyay (IITA-Nigeria), Jendeka Mabel Mahasi (KARI-Kakamega, Kenya), Robert Abaidoo (IITA-Nigeria), Bussie Maziya-Dixon (IITA-Nigeria), Alpha Kamara (IITA-Nigeria), Ousmane Coulibaly (IITA-Cotonou), Ousmane Boukar (IITA-Nigeria) and David Chikoye (IITA-Zambia), Penina Muoki (IITA-Mozambique), Joseph Mligo (ARI- Ilonga, Tanzania)

Socio-Economics/Targeting

Gap and PVS analysis

Surveys were carried-out with a set of questionnaires that were administered on scientists, extension agents, farmers and other relevant key informants. The study concludes that soybean has a significant potential for income if a conducive policy for input supply, production and marketing is developed and implemented. A fragile and poorly defined relationship was observed among stakeholders in soybean innovation systems and value chains. Linkages need to be developed and/or strengthened. Furthermore, a more focused approach and coordination of efforts of all the stakeholders is needed to bridge these gaps, boost production and increase value added and ultimately increase food supply and incomes. Research is still needed to assess and quantify the actual and potential impacts of the adoption of improved varieties on farmer's welfare, nutritional status, gender relations, soil fertility improvement, and crop-livestock integration systems.

Situation and outlook

Analysis of soybean supply and demand situation and outlook showed that global soybean production and trade is characterized by a high level of concentration and specialization. While the United States, Brazil, and Argentina alone account for over 80% of the world soybean production, Africa's share is less than 1%. As the three leading soybean exporters, the United States, Brazil, and Argentina continue to account for nearly 90 percent of the world's aggregate exports of soybeans, soybean meal, and soybean oil during the coming decade. If past trends in soybean area expansion and yields continue into the future, global soybean production is projected to reach an estimated 293 million tons in 2020 and 360 million tons in 2030. While particular regions and countries in the developing world will face serious shortages, others will have surpluses. Asia, for example, is projected to have a deficit of over 65 million tons of soybean in 2020 and 87 millions in 2030, whereas Africa is projected to have a deficit of 196,000 tons in 2020 and 450,000 tons in 2030. The projections showed that developing countries, including Africa, are the main source of growth in world soybean demand and trade. A number of factors have generated fresh and growing demands for soybeans-for domestic processing to meet the rising domestic demand for soybean meal and soybean oil. In Malawi, for example, trade policy measures intended for protecting the poultry industry-import quota for poultry meat-have resulted in a substantial increase of demand for soybeans primarily to supply the feed industry, with positive prospects for edible oil. This change in trade policy encouraged the rapid growth of the local feed industry, with increased derived demand for soybean and soybean cake. However, the growing domestic and regional demand for soybean is unlikely to be satisfied through domestic and regional production without major research and development investments aimed at raising the productivity, profitability, and competitiveness of smallholder soybean production. In many instances, farmers use farm-saved seeds of low-yielding varieties because seeds of improved varieties are not accessible. Increased adoption of high-yielding varieties and other inputs will require effective and efficient extension, credit, and input supply systems.

Adoption studies

Adoption studies for soybean technologies in Northern Nigeria were undertaken within the framework of the Tropical Legumes II (TL II) project show that the most popular soybean varieties used by farmers are TGX 1955-5F and TGX 1858-20E. The most important characteristics in assessing improved soybean quality are grain yield, grain quality, adaptability, fodder yield and early maturity. Most farmers rely on international/national research institutes and public extension services as the first source of improved seed. With respect to the degree of adoption, the proportion of land allocated to improved varieties averages 36% of the total land cropped to soybean. The likelihood of adopting improved varieties is affected by farmer's age and gender, access to information, frequency of contact with extension agents, experience in soybean production, and availability of seed market. The intensity of adoption is influenced by farmers' level of education, availability of non-farm income, experience in soybean production and number of fields owned by farmers. Policies aiming at increasing improved seeds access such as public and private partnerships to promote community-based and private seed multiplication and enhancement of farmers' participation in improved soybean promotional activities may lead to significant increases in access to improved seeds and sustain the use of improved seeds at large scale.

Baseline studies

Soybean is one of the most important and fastest growing oil-bearing crops in the world. Soybean accounts for 37% of the global area under oilseeds, and contributes 28% to vegetable oil production. Its production has been growing at 4.7% per annum with yield and area growths of 1.3% and 3.3% per annum respectively. Its growth has been driven more by area increases than yield improvements. The crop's adaptability to varied agro-ecological environments, namely the tropics, subtropics and temperate is one of the main reasons for its rapid spread across the globe. Soybean grows in all places and matures in 3 to 6 months. The pod is hairy and contains two to three seed. It grows best if planted in pure stands. The crop also improves soil fertility by fixing nitrogen from the atmosphere. Some varieties fix 44 to 103 kg N per hectare annually and some varieties can yield as higher as 3 MT per hectare. Across the globe, soybean has a wide diversity of varieties. The continent's largest producer is Nigeria. Some of the varieties popularly grown by farmers throughout the world including Nigeria are: M351, Samsoy 1 and 2, TGx 536-02D, TGx 923-1E, TGx 1440- 1E, TGx 1448-2E, TGx 306-036C, and TGx 1485-1ED.I Improved soybean varieties released in Nigeria in particular include TGx 849-313D, TGx 1019-2EN, TGx 1019-2EB, TGx 1447-2E, TGx 536- 02D, TGx 306-036C, TGx 1485-1ED, and TGx 1440-1E.

Soybean is a high-value nutritive crop and it plays a significant role in overcoming problems of food and nutritional insecurity, especially in developing countries. For instance studying the impact of soybean adoption in Nigeria using a Social Impact Assessment framework found that the adoption of soybean had a clear positive impact on household income generation and distribution, material welfare, human capital development, gender relations, resource use, social equity, and other social processes in the community.

Production trends

The world's soybean area has expanded rapidly during the past decade. It increased by 50 million hectares from its initial level of 38 million hectares in the 1970s to 88 million hectares in the 2000s. As indicated in Figure 11-1 below, Africa has a very low share of global area cultivated. South America has the largest share of area cultivated (40%) followed by North America (35%) and Asia (21%). Europe accounts for 2% while Africa accounts for about 1%. The rest of the world accounts for about 1%. North America's share is accounted for mostly by the United States of America which has 34% of global area cultivated. In terms of shares of global area cultivated, Brazil (22%), Argentina (15%), China (11%) and India (9%) are the largest after the USA. The total area cultivated in Africa is about 1.1 million hectares. In Africa, the countries with the largest area cultivated are Nigeria (578, 753 ha), South Africa (156,394 ha) and Uganda (142,700 ha). Thus, Nigeria accounts for about half of the area cultivated in Africa. Aside from these three countries, African countries generally have low acreage of less than 100,000.

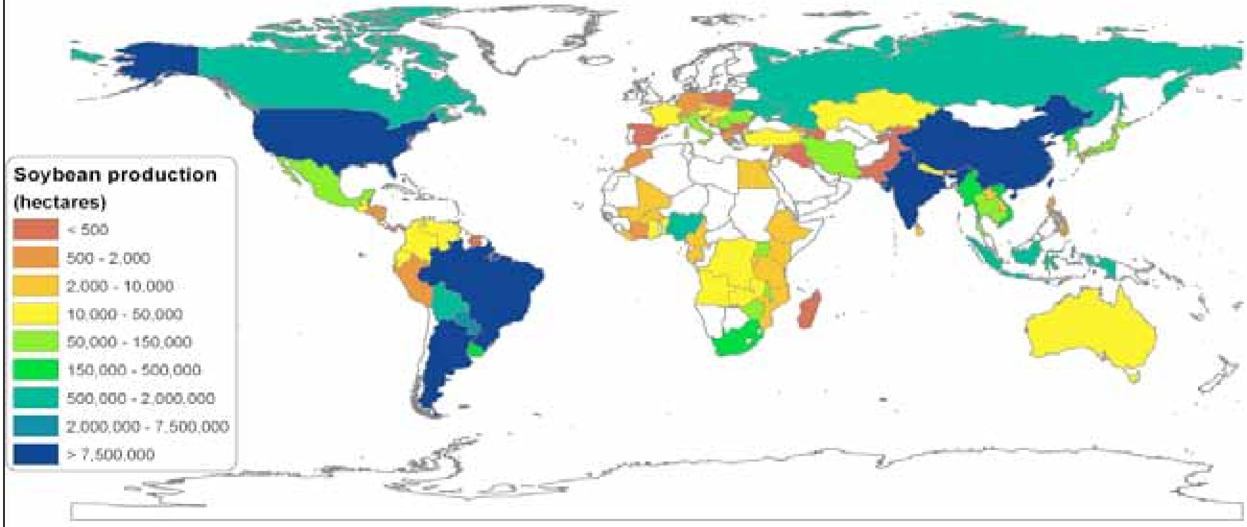


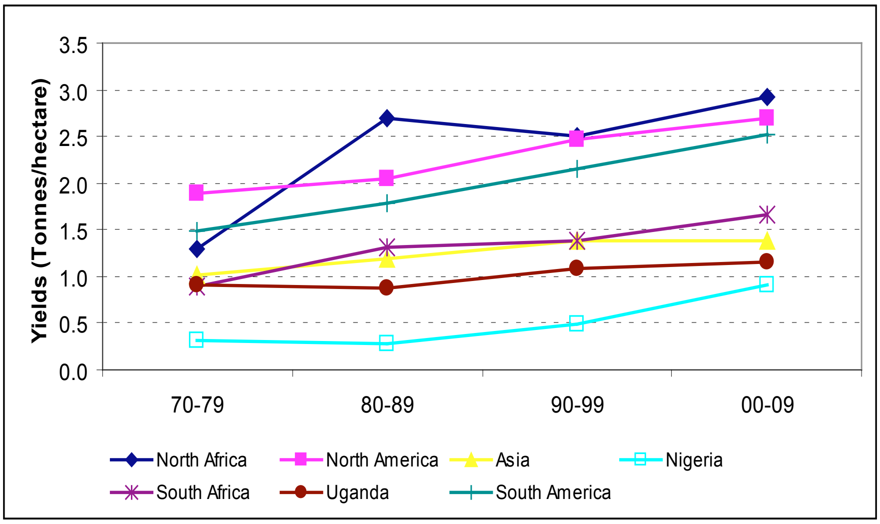
Figure 11-1: World soybean areas

In the last four decades the global annual growth in area cultivated was about 3%. Although Africa's growth was higher at 5% per annum, its share of global area cultivated has remained about 1% in the last four decades. It however has been increasing slowly from .7% in the 1970s to 1.3% in the 2000s. The region which recorded the highest growth in area cultivated was Oceania at 21% average annual growth rate while North America recorded the least growth of 2%. The highest growth rate in Africa was in Central Africa with 15%. Nigeria and West Africa as a whole recorded a growth rate of 5% while South Africa and Uganda recorded area growths of 12% and 13% respectively.

In the 2000s average soybean yield was 2.3 MT per ha, which is an improvement on the 1.6 MT per hectare achieved in the 1970s. In the last 4 decades, yield has been increasing at 1.3% per annum. Figure 11-2 below indicates that there are clear variations across the world in terms of yield. In the 2000s, North Africa had the highest yield at 2.9 MT per ha while Central Africa had the lowest yield of 0.5 MT per ha. South America, North America and Asia, which collectively account for 96% of global area cultivated had yields of 2.5, 2.7 and 1.4 MT per ha, respectively. Nigeria and West Africa as a whole had a yield of 0.9 MT per ha. South Africa and Southern Africa as a whole had a yield of 1.7 MT per ha while Uganda and East Africa as a whole had yields of 1.1 MT per ha.

The inter-country yield disparities are reflective of farming systems and technology differentials that exist among the regions. The larger and well mechanized farms of North and South America are often planted to very high yielding varieties and operated by resource rich farmers often supported by deliberate government policy whereas Indian, Chinese and African farms are mainly smallholder operated, planted to relatively low yielding varieties which are prone to pests and diseases.

Nigeria, South Africa and Uganda which account for 77% of area cultivated in Africa experienced increased yields in the last 4 decades as other regions of the world did. Although South Africa, Uganda and Asia had about the same yield in the 1970s, South Africa improved on its yields more so that by the 2000s there was a clear difference in their yields. The most impressive increase was recorded by North Africa which started as the third highest in the 1970s but grew to clearly overtake other regions by the 1980s and maintained its position up to the 2000s.



Source: Authors using FAO data

Figure 11-2: Trends in Soybeans yield across the world (1970 – 2009)

Soybean output increased significantly from an average of about 60 million MT in the 1970s to about 200 million MT in the 2000s. In the last four decades, production has been growing at 4.7% per annum. In the 2000s, South America accounted for 90 million MT (44% of global production), followed by North America, which accounted for 82 million MT (41% of global production). Asia ranked third at 23 million MT (13% of global production). In South America, the major producers are Brazil and Argentina which account for 24% and 17% of global production. In North America, the United States accounts for almost all the output and produces about 40% of global production. Thus, the US, Brazil and Argentina account for over 80% of global production. Africa accounts for 1.2 million MT (about 1% of global production) annually.

In the last four decades South America had the highest average annual growth rate of 12% and succeeded in increasing its share of global production from 13% in the 1970s to 44% in the 2000s. North America which had the highest share of 68% in the 1970s grew at 4% and had a lower share of 41% by the 2000s. Asia also experienced a reduction in its share from 16% in the 1970s to 13% in the 2000s. Africa with 8% annual growth rate increased its share from .3% in the 1970s to .6% in the 2000s. Thus there has not been any significant change in Africa's share of world soybean output which has remained at less than 1% since the 1970s.

Within Africa, Nigeria, South Africa and Uganda account for about 43%, 22%, and 13% of its production respectively, implying that Nigeria is the continent's leading soybean producer contributing about 0.5 million MT of soybean to total world production. South Africa and Uganda produce about .3 and .2 million MT respectively. These 3 countries account for about 80% of soybeans production in Africa. Among the 3, South Africa experienced the highest growth rate of 25% with production increasing from 7,700 MT in 1970 to 516,000 in 2009. Uganda had a growth rate of 14% with production increasing from 5000 MT in 1970 to 180,000 in 2009. Nigeria also had a high growth rate of 9% with production increasing from 58000 MT in 1970 to 573,863 MT in 2009.

In Nigeria, adaptation and successful incorporation of soybeans into the maize-based cropping system, local dishes, and family diets were instrumental to the increase in soybean production while development of simple methods of soybean processing for home consumption also played a key role just like the response to the needs of local markets, supported by profitability. Benue State, in Nigeria has the longest history of soybean cultivation and it is estimated that the state accounts for over 70% of soybean production. Although Africa lags behind the rest of the world in soybean production, since the 1970s some National Agricultural Research Systems (NARS) in Africa and other research agencies have shown immense interest and commitment to expanding soybean production and utilization such that soybean breeding work is on-going in a number of places. This suggests that the future soybean situation for Africa may change.

Production constraints and gaps

Poor information on improved varieties

Farmers who work directly with research institutes and extension agents have access to information and improved varieties seeds through participation in on-farm trials and farm visits. However, information sharing between trained farmers and other farmers is still limited by educational, socio-economic, policy and institutional barriers (e.g. number and type of training received, extent of contact with extension agents and/or scientists).

Public support for research and extension

Although the usefulness of soybean research and development projects is clearly reflected in an increased average yield from 300 kg to 1500 kg in Africa (FAOSTAT, 2006), public support for soybean value chain development is limited. Subsidies, for example, are limited or non-available. Also effective access to marketing devices and reliable input and product markets has to be promoted.

Assessing constraints and opportunities

Soybean production, processing and marketing in West Africa take place in an ever-changing environment and so does agricultural research. However opportunities are arising from economic growth and regional trade. Income drives the demand for high-quality soybean grains and processed products. Biotic and abiotic constraint like pests, diseases, drought and market access mainly for soybean are threats to food security, poverty reduction and enhanced livelihoods. Research priorities need to be updated to take into account these constraints and opportunities. This will require ex ante impact assessment aimed at identifying potential gains from technologies and novel institutional arrangements and priority setting.

Important variety traits from users' perspective

One of the reasons for low adoption of improved varieties is argued to be the fact that most improved varieties lack end-users' preferences. This has been gradually corrected by crop improvement programs which involve farmers, consumers and processors/traders through PVS and trait-based surveys in the process of developing improved varieties to meet preferences. The baseline survey data collected on variety trait preferences of soybean producers in Malawi and Mozambique have shown that in Malawi, about 60% of soybean producers indicated a clear preference for improved varieties with higher yields. Larger grain size and earliness of maturity are are also important. While high-yielding variety preferences are equally strong among male- and female-headed households, earliness is more important than grain size for female-headed households. In Mozambique, most soybean producers indicated a clear preference for improved varieties with high grain yield as well as attractive prices. As soybean is a relatively new crop in Mozambique and is grown mainly for cash, the survey results confirm that the market is the main driver of soybean production.

Table 11-1: Preferred soybean traits in Malawi and Mozambique

Criterion	Men	Women	Both
Malawi			
Grain yield	57	63	59
Seed size	12	7	11
Earliness	9	11	10
Mozambique			
Price	43	56	44
Grain yield	41	44	42
Earliness	10	NA	10

Note: Some of the columns do not add up to 100 because of other preferred traits
Source: TL II Surveys, 2008

Supply of important traits by the improved varieties

When IITA started soybean breeding, yields were less than 500 kg per ha in Nigeria and in most African countries but through the use of IITA varieties, the national average yield has increased by more than 50% in West African countries. Of equal importance is the fact that through IITA's breeding work on soybean, a genetic gain of 2.1%, 3.2% and 3.6% per year for early, medium and late varieties, respectively, has been realized in two decades.

Across the globe, soybean has a wide diversity of varieties; however, some of the varieties popularly grown by farmers in Nigeria are: M351, Samsoy 1 and 2, TGx 536-02D, TGx 923-1E, TGx 1440- 1E, TGx 1448-2E, TGx 306-036C, and TGx 1485-1D, and improved soybean varieties released in Nigeria include TGx 849-313D, TGx 1019-2EN, TGx 1019-2EB, TGx 1447-2E, TGx 536- 02D, TGx 306-036C, TGx 1485-1D, and TGx 1440-1E. A good number of the improved varieties are a result of IITA's breeding work. Again, IITA has developed a large number of superior promiscuous soybean lines ready to be utilized by national programs for testing and release as new varieties. In the early, medium and late maturity groups there are 35, 30 and 21 lines available, respectively.

Baseline status of adoption of improved varieties

Early adoption of improved varieties in northern Nigeria

Farmers have been using improved soybean varieties since the 1970s with a level of awareness varying from 2% to 15% in 2005 and a peak of 59% between 2006 and 2010. TL II project made some contribution through on-farm trials, demonstrations, seed multiplication and delivery. The frequency of farmers using improved varieties for the first time increased gradually from 2% to 13.4% from 1986 to 2000 and peaked at 79% in the period over which the TL II project was implemented. The adoption rate calculated using the proportion of farmers who have growing at least one improved soybean variety during the promotional soybean varieties activities initiated under the TL II project is therefore estimated at 79%. The improved soybean varieties introduced include *TGX 1955-5F* the most popular, followed by *TGX 1835-20e* and *TGX 1448-2e* (7% of respondents). Other varieties like *TGX1940* (.21% of respondents) *TGX1950, TGX1951 and TGX1954* have lower adoption rate.

Assessing determinants of farmers' participation in TL II soybean promotion activities

The involvement of farmers in seed multiplication programs has been important in raising awareness about improved varieties. Results from the surveys indicate that adoption of improved varieties of soybean promoted under TL II project is influenced by gender, access to information (contact with research and extension) experience in soybean production and availability of markets for input and products.

The degree of adoption of soybean varieties is measured by the proportion of land cropped with the various soybean varieties**.** Among the improved varieties, *TGx 1955-5F* occupies 36% of farm land, followed by *TGx 1835-10E* (15%), *TGx 1830-20E* (9.4%), *TGx 1448-2E* (9%) and *TGx 1904-6F* (8%). The average area of land cropped for soybean at household level is 0.72 ha.

Farmers' access to other sources of income outside farming activities is important in the adoption of improved varieties of soybean. This implies that the intensity of adoption depends on external source of income. The extra income generated can be used to purchase farming inputs (seeds, chemicals, labour). It may also be that the farmer is more ready to risk his farm income by using improved varieties because his income sources are diversified. Nothing stops the farmer from using income from local varieties to fund other inputs if he believes he'll make more money using improved varieties. Also, it may be that the real correlation is between (farmer's income level * adoption rate) and that farmers with higher non-farm income tend to be richer.

Seed supply systems and demand constraint

Nigeria

IITA is currently leading three major projects on cereal and legumes in Northern Nigeria:

i) The Legumes for Livelihood Project;
ii) The Sudan Savannah taskforce of the Kano-Katsina-Maradi pilot learning site;
iii) Promoting Sustainable Agriculture in Borno State.

Since all three include a seed systems component, the seed system study covers areas of all three projects. TL II is focusing on 3 states (Borno, Kano and Kaduna) and 2 crops (cowpea and soybean). In Kano and Katsina States, availability of quality seeds of the main cereal and legume crops has been identified as a key constraint to adoption of new varieties. Knowledge of the current seed systems in the project area is an initial necessary step to address the seed availability problem. In Borno State, prior to PROSAB and CIDA funded project, the only improved seeds available to farmers were maize hybrids which are not resilient to the constraints in these drought-prone areas. To mitigate drought and striga impact, IITA introduced a number of improved crop varieties in Borno, Kano and Katsina including maize, sorghum, rice, cowpeas, soybeans and groundnuts. To ensure ongoing availability of improved seeds, PROSAB selected and trained seed producers and assisted them in establishing community-based seed multiplication schemes in 30 communities in southern Borno covering three agro-ecological zones. There are prospects that some of these seed producers will develop self-sustaining rural enterprises with capacity to meet the demand for improved varieties seeds for farmers within and around the communities. However, access to quality, affordable, and sustainable improved seeds remains a concern.

Seed systems in Malawi

In Malawi, the Department of Agricultural Research Services (DARS) is responsible for the production and distribution of basic or foundation seed. However, the level of investment is so variable and usually leads to erratic supply of basic seed. No adequate basic seed was available at the start of 2007 season such that multiplication had to be done using certified soybean seeds. Currently, production is undertaken under the DARS Basic Seed Up-scaling Program. Potential farmers apply and successful applicants are then supplied with breeder seed to produce basic seed under inspection of the Seed Services Unit. The basic seed is then sold through the program management unit. In 2008, nearly 7 MT of Basic Seed was produced (Table 11-2).

Table 11-2: Basic seed production in Malawi, 2008

Variety	Quantity (MT)
Ocepara-4	0.70
427/5/7	1.95
747/6/8	3.65
Magoye	0.20
Total	**6.50**

The up-scaling program signals the public sector efforts to improve the production and distribution of basic seed of soybean. As opposed to past basic seed production initiatives, the up-scaling program is more organized. For instance, the varieties that are multiplied under this program are chosen based on farmer and consumer preferences and the seed production is undertaken by farmers with inspection and other technical support from the Seed Services Unit.

Certified seed production and demand in Malawi

Production of soybean seed is concentrated in the main soybean producing areas of Lilongwe, Kasungu, and Mzuzu. The main actors in soybean seed production in Malawi are the Association of Small-Scale Seed Multipliers Action Groups (ASSMAG) and SeedCo. ASSMAG is a farmer-owned rural seed production and marketing organization in Malawi and was formed in 2001 as a successor to the National Smallholder Seed Producer Association (NASSPA). All certified seed produced under ASSMAG is bulked and sold to NGOs (World Vision International-Malawi, Action Relief, Christian Health Association of Malawi, Catholic Development Commission of Malawi) that either distribute it for free or under a revolving credit scheme. The main soybean seed producing associations are Mzuzu, Bua, and Chigwa in Mzuzu, Kasungu, and Salima Agricultural Development Divisions (ADDs), respectively. In 2007, ASSMAG accounted for 95% of total certified soybean seed production in Malawi. On the other hand, SeedCo is a private seed company that is involved in production and distribution of soybean seed in Malawi—registered in 1999 and started operations in 2000. The company produces seed of two varieties (Soprano and Solitaire). These varieties were developed by SeedCo–Zimbabwe and released in Malawi in August 2003. SeedCo produced about 111 MT in 2005 and 300 MT in 2006—both through its out-growers. In 2006, SeedCo accounted for about 50% of total soybean seed production in Malawi.

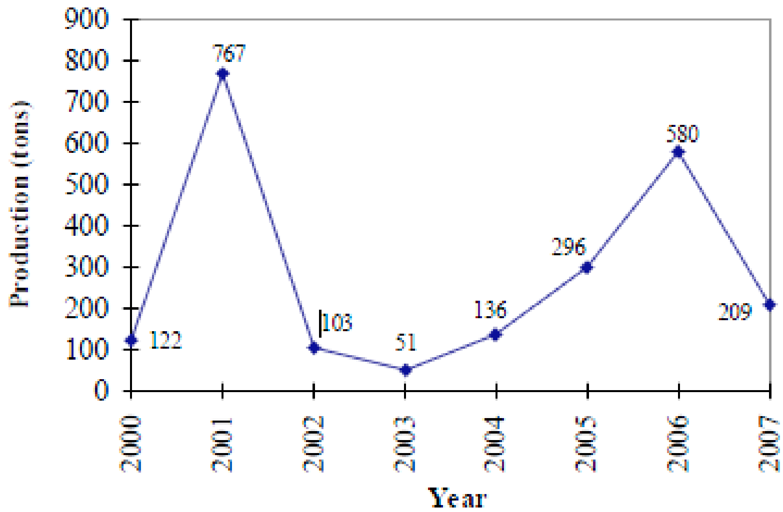


Figure 11-3: Soybean seed production in Malawi, 2000–2007

Soybean seed production in Malawi has exhibited significant fluctuation over the period 2000–2007 (Figure 11-3). Production increased from only 122 MT in 2000 to 767 MT in 2001, but then declined sharply to almost 50 MT in 2003. The sharp increase in seed production in 2001 was largely due largely to: (1) community-based seed production initiatives involving NASSPA with funding from foreign sources (e.g., European Union), and (2) seed production by Monsanto.

Seed systems in Mozambique

Soybean seed multiplication is solely undertaken by community-based associations that are members of IKURU. IKURU is a farmer-owned commercial entity that works with local out grower associations for cowpea and soybean in Nampula and Zambezia. It procures basic seed of cowpea—mainly IT-18—from the Basic Seed Unit of IIAM (USEBA) and basic seed of soybean—mainly Santa Rosa and Storm—from seed companies in Zambia and distributes it to farmers through the affiliate associations. All the seed multiplied under this scheme is sold to IKURU after it has been thoroughly cleaned and treated with *actellic* dust. The seed is later sold to agro-dealers, government projects, and NGOs at a whole sale price while part of it is sold on the retail market through IKURU retail shops.

In a situation where most of the farmers rely on their own farm-saved, recycled seed, lack of effective improved seed demand will continue to be a critical constraint to the development of the seed sector. There is no premium price for improved seed and hence seed subsidies may need to form part of the overall strategy to promote adoption of improved varieties. Seed credit or subsidies, coupled with greater popularization activities, is thus needed to create awareness and market demand for improved seed. Apart from lack of economic access, many farmers also have neither the information nor the physical access to improved seed. Therefore, improved access to credit, extension, and information and market infrastructure would be a key component of an overall strategy aimed at enhancing farmer access to improved seed and other complementary inputs.

Human capacity building

Number of trained technicians and enumerators in West Africa

Countries	Enumerators	Technicians	Total
Nigeria	60	6	66
Niger	20	2	22
Mali	20	2	22
Total	**100**	**10**	**110**

More than 40 enumerators in total or 20 enumerators per country were trained in baseline surveys methodology and questionnaires-seed systems analysis and early adoption of improved varieties.

Major lessons learned

The majors lessons learnt from the implementation of TL II –Objective 1 are:

- Capacity building of scientists in socio-economic tools and methodologies needs to be strengthened;
- Strengthening NARS partners in economic analysis, and related novel methodologies;
- More focus on value chain approach which is well integrate both varieties/seeds; crop management; IPM; benefits and costs; and impacts ;
- Strengthen the capital of knowledge and information for on-going countries and train actors from other countries on these experiences.

Fast-Track Testing of Soybean Elite Lines

PVS has been carried out in five project countries (Malawi, Mozambique, Nigeria, Kenya and Tanzania) using available varieties and elite lines of soybean to fast track the release and availability of varieties with the shortest possible time.

In Malawi PVS trials started in 2007/08 with three released varieties in the country. Of the three varieties, *Ocepara-4* gave the highest grain and fodder yields (Table 11-3). In the second year, PVS trials were carried out using new lines from fast-tracking. Among the new test lines, TGx 1740-2F gave the highest on-farm yield of 1415 kg per ha across three districts of Malawi (Table 11-4). The widely grown check variety (*Magoye*) gave 733 kg per ha in the same trial. In the third year PVS trial, differences among genotypes were significant in all districts of Malawi (Table 11-5). On average, high on-farm yield was obtained from Dowa (2364 kg per ha) followed by Lilongwe (2216 kg per ha) and Dedza (1652 kg per ha). Similar to the previous year trial, TGx 1740-2F gave a consistently high grain yield in all districts. Across districts, TGx 1740-2F out-yielded the rest of the materials grown with an average yield of 2248 kg per ha. This yield figure across all districts is significantly higher than the check varieties *Nasoko* and *Magoye*. It surpassed *Nasoko* and *Magoye* by 15% and 38%, respectively. Farmers ranked the test genotypes for various crop growth and post-crop growth traits. For each trait scores of 1-10 were given, where 1= not liked and 10= most liked by farmers. Overall results showed that TGx 1740-2F had the highest scores in many growth traits like earliness, vigor, biomass, pod filling, pod health, seed size followed by *Nasoko* (Table 11-6).

Table 11-3: Grain and fodder yields (kg per ha) of three varieties in PVS trials across four districts (Lilongwe, Dedza, Dowa and Kasungu) in Malawi - 2007/08 growing season

Variety	Grain yield	Fodder yield
Ocepara-4	1467	1399
Nasoko	1308	1188
Makwacha	1245	1255
Mean	1340	1281
SE	119	98
P	0.4046	0.3881

National average for 2006/07 was 700 kg per ha, thus the increase ranged from 78% to 109%

Table 11-4: Grain yield (kg per ha) of soybean lines in PVS trials in four districts of Malawi - 2008/09 growing season

Genotype	Lilongwe	Dedza	Dowa	Mean
TGx 1740-2F	1820	1100	1326	1415
TGx 1830-20E	1530	860	1016	1135
TGx 1835-10E	1220	720	814	918
Magoye	1120	506	573	733
Mean	1423	797	932	1050
SE	106	81	39	46
P	0.0021	0.0017	<0.0001	<0.0001
CV (%)	17	23	9	17
LSD (0.05)	325	250	119	132

Table 11-5: Grain yield (kg per ha) of soybean genotypes in on-farm PVS trials in four districts of Malawi - 2009/10 growing season

Genotype	Lilongwe	Dedza	Dowa	Kasungu	Mean
TGx 1740-2F	2450	2017	2901	1626	2248
Nasoko	2276	1663	2420	1442	1950
TGx 1835-10E	2307	1774	2304	1374	1939
TGx 1830-20E	2023	1486	2124	1372	1751
Magoye	2020	1375	1815	1287	1624
Mean	2216	1652	2364	1414	1991
SE±	97	57	65	56	46
LSD (0.05)	404	205	250	190	140

In Mozambique, PVS trials were setup across five communities in high potential soybean growing areas in Zambezia Province (Table 11-7). The trials were carried out in 2008/09 season using five genotypes (TGx 1740-2F, TGx 1485-1D, TGx 1937-1F, TGx 1908-8F and TGx 1904-6F). A total of 68 farmers (46 men and 22 women) were involved. Three genotypes were planted on each farm. Four locally grown varieties: Storm, Santa Rosa, Safari and Santa were used as checks. The yields for the new genotypes were higher than that for the varieties planted by the farmers at all locations except Lioma, where yield for Storm was similar to that for the new genotypes (Table 11-8).

Table 11-6: Farmer PVS scores[1] of crop growth traits of soybean genotypes grown in four districts (Lilongwe, Dedza, Dowa and Kasungu) of Malawi - growing 2009/10 season

Genotype	Earliness	Expected yield	Vigor	Poor soil tolerance	Biomass	Pod filling	Pod health	Pod number	Seed number
TGx 1740-2F	9.5	8.1	8	8.2	7.5	8.2	8.6	8.2	8.8
Nasoko	7.9	8.1	7.8	6.3	7.7	8.6	8.6	7.9	8.8
TGx 1835-10E	7.9	7.7	7.5	7.6	7.0	7.8	8.3	7.5	8.2
TGx 1830-20E	7.2	6.9	7.6	7.7	7.5	7.6	8.2	7.2	8.4
Magoye	6.3	6.7	8.3	7.4	8.3	7.4	7.9	7.6	7.7
Mean	7.8	7.6	8.1	7.4	7.8	8	8.5	7.8	8.6
SE±	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3
LSD (0.05)	0.5	0.8	NS	0.8	0.7	0.7	NS	0.6	NS

[1]For each trait scores of 1-10 were given, where 1= not liked and 10= most liked by farmers.

During the 2009/10 season, PVS trials were setup across five communities in major soybean growing areas in Zambezia Province: Lioma, Maggige, Tetete, Ruace and Napalame (Table 11-9). Seventy-four farmers (35 females; 39 males) in the five communities were involved. Data from the trials indicated that the yields for the new genotypes in general were two to three times higher than the local checks in all the communities (Table 11-10).

Table 11-7: Communities and farmers involved in farmer-managed PVS soybean trials in Zambezia Province, Mozambique - 2008/09 growing season

Community	Men	Women	Total
Ruace	22	8	30
Lioma	3	3	6
Tetete	7	8	15
Serra	11	2	13
Maggige	3	1	4
Total	**46**	**22**	**68**

Table 11-8: Mean grain yield (kg per ha) of soybean genotypes in farmer-managed PVS trials in five communities in Zambezia Province, Mozambique- 2008/09 growing season

Genotype	Ruace	Tetete	Magige	Lioma	Serra
TGx 1740-2F	3348a	2100a	3117a	3013a	2431a
TGx 1908-8F	3129bc	1956ab	2883a	2904a	2171b
TGx 1904-6F	3002c	1839a	2925a	2652a	2065b
TGx 1937-1F	3083c	1904ab	2967a	2584a	2095b
TGx 1485-1D	3220ab	2075a	3033a	2719a	2212ab
Storm (check)	2397d	-	-	2585a	1610c
Santa Rosa (check)	1770e	1217c	1750b	1625b	1255d
Safari (check)	1567e	1049c	251c	-	1810bc
Santa (check)	1771e	576d	-	1734b	-
CV (%)	7.07	14.79	6.98	13.65	10.69
P (Genotype)	<0.0001	<0.0001	<0.0001	0.0046	<0.0001

Means, within a column, followed by the same letter are not significantly different at 5% probability level.

Table 11-9: Communities and famers involved in farmer-managed soybean trials in Zambezia Province, Mozambique - 2009/10 growing season

Community	Men	Women	Total
Lioma	1	2	3
Maggige	3	2	5
Napalame	3	3	6
Ruace	30	23	53
Tetete	2	5	7
Total	**39**	**35**	**74**

Table 11-10: Mean grain yield of soybean genotypes grown in farmer-managed PVS trials across several communities in Zambezia Province, Mozambique - 2009/10 growing season

Genotype		Location Yields (kg per ha)				
		Ruace	Tetete	Magige	Lioma	Napalame
TGx 1740-2F		3245ab	2575a	2822a	3242a	2482a
TGx 1908-8F		3114ab	2352b	2877a	2904a	2406a
TGx 1904-6F		3749a	2624a	2940a	3041a	2494a
TGx 1937-1F		2760b	2353b	2775a	2916a	2417a
TGx 1485-1D		2745b	2166c	2766a	2817a	2434a
Local checks	Storm	2539bc	1418d	2313b	1992b	1232b
	Santa Rosa	1532cd	930e	-	1617b	824b
	Safari	1366cd	-	-	-	-
	Santa	718d	936e	1045c	-	848b

Means, within a column, followed by the same letter are not significantly different at 5% probability level

In Nigeria, the first year (2008) on-farm trial involved TGx 1835-10E (a rust resistant breeding line in previous work), and TGx 1485-1D (rust-susceptible released cultivar) at 13 sites in eight states encompassing three agro-ecological zones. The states were (with site names in parenthesis) Benue (Yandev and Makurdi), Kaduna (Zonkwa and Samaru-Kataff), Kogi (Aiyetoro and Isanlu), Kwara (Eyenkorin), Nassarawa (Keffi and Lafia), Osun (Ilesha), Oyo (Onilaru and Oniyo), and Taraba (Jalingo). TGx 1835-10E was found to be resistant to rust at all locations whereas the long time released variety TGx 1485-1D had nearly 24% damaged leaf area at locations where rust was prevalent. Mean grain yield of TGx 1835-10E was 25% more than TGx 1485-1D at locations where rust severity was high. Based on this trial, particularly for its rust resistance, the Nigerian Plant Variety Release Committee in its meeting in December 2008 approved the registration and release of TGx 1835-10E for general cultivation in the country.

In the 2010 PVS trials, a total of 175 farmers from four states (Kaduna, Benue, Kano and Niger) participated. Sixty-five farmers participated from each of Kaduna and Kano states whilst 35 and 10 farmers participated from Benue and Niger states, respectively (Table 11-11). Across all test genotypes, the highest on-farm yields from the baby trials were obtained from Benue/Yandev (1700 kg per ha), Kaduna/Samaru Kataf (1642 kg per ha), Kano (1629 kg per ha) and Niger/Mokwa (1626 kg per ha) (Table 11-12). At Maigana, another site in Kaduna State, grain yields were relatively low (1221 kg per ha). Except for Maigana and Mokwa/Niger sites, TGx 1987-10F gave the highest grain yield at Kano (1826 kg per ha), Kaduna/Samaru Kataf (1720 kg per ha) and Benue/Yandev (1817 kg per ha). Across all states and farmers, TGx 1987-10F turned out to be the top yielder (1626 kg per ha), followed by TGx 1835-10E (1619 kg per ha) and TGx 1448-2E (1594 kg per ha). TGx 1987-62F and TGx 1987-10F gave the highest fodder yields across all states and farmers (Table 11-13). In terms of rust incidence, the resistant lines (TGx 1987-10F, TGx 1987-62F and TGx 1835-10E) were free from the disease. The disease, however, appeared on genotypes such as TGx 1485-1D, TGx 1448-2E and NCRISoy8 with incidence percentages ranging from 1% - 9.4%. The high yielding genotypes were also early maturing and took 75-83 days to mature across all states and farmers. TGx 1448-2E and NCRISoy8 took 99 and 106 days to mature, respectively. The late maturing variety (TGx 1448-2E) produced the highest number of pods per plant as compared to the other genotypes. Similar to the baby trials, TGx 1987-10F was found to be the top yielder (1916 kg per ha) in the mother trials across six sites in four states (Table 11-14). It was followed by TGx 1448-2E (1905 kg per ha) and TGx 1987-62F (1767 kg per ha). With the exception of NCRISoy8 and TGx 1448-2E, all the other genotypes were found to be early maturing.

Most farmers in Kano state of Nigeria prefer TGx 1835-10E (variety released in 2008) because of its early maturity. This according to them would be adequate for their environment, especially when there is unreliable rainfall and thus they are prone to drought. TGx 1987-10F and TGx 1987-62F yielded higher than other varieties and also has attractive golden seed color, but matured later than TGx 1835-10E. In Benue State (Yandev), the reaction of the farmers is different. The farmers prefer TGx 1987-10F and TGx 1987-62F because of the number of branches per plant, height of plant, seed color and their high yield. According to the farmers, TGx 1835-10E will mature before the rainy season is over and may be a problem as there would be no place to dry the harvest. Other farm activities may also require attention at the time of its maturity. One of the women farmers (a widow), however, prefers TGx 1835-10E for its earliness as she will be able to get money quickly to pay her children's school fees. Most farmers across the states, however, gave general recommendations on the improved varieties as none of them shatter on the field compared to their local ones.

Table 11-11: States, locations and number of farmers where on-farm PVS trials were carried out in Nigeria in 2010

State	Location	No. of farmers
Kaduna	Maigana	30
Kaduna	Samaru Kataf	35
Kano		65
Benue	Yandev	35
Niger	Mokwa	10
Total		**175**

Table 11-12: Grain yield (kg per ha) of soybean genotypes under on-farm PVS baby trials in four states in Nigeria - 2010

Gonotype	Kano	Kaduna (Maigana)	Kaduna (Samaru Kataf)	Benue (Yandev)	Niger (Mokwa)	Average
TGx 1987-10F	1826	1113	1720	1817	1655	1626
TGx 1987-62F	1709	1178	1697	1647	1605	1567
TGx 1835-10E	1775	1313	1611	1711	1683	1619
TGx 1485-1D	1343	1255	1586	1647	1617	1490
TGx 1448-2E	1618	1255	1699	1725	1673	1594
NCRI Soy 8	1502	1209	1536	1650	1525	1484
Mean	1629	1221	1642	1700	1626	1563

Table 11-13: Fodder yield (kg per ha) of soybean genotypes under on-farm PVS baby trials in four states in Nigeria - 2010

Gonotype	Kano	Kaduna (Maigana)	Kaduna (Samaru Kataf)	Niger (Mokwa)	Average
TGx1987-10F	1371	1478	1360	1275	1371
TGx1987-62F	1331	1782	1330	1310	1438
TGx1835-10E	1326	1134	1311	1307	1270
TGx1485-1D	1316	1121	1288	1263	1247
TGx1448-2E	1216	1132	1385	1348	1270
NCRI Soy 8	1247	1141	1294	1250	1233
Mean	1301	1298	1328	1292	1305

Table 11-14 Average performance of soybean genotypes for six traits in on-farm PVS mother trials in four states in Nigeria - 2010

Gonotype	Grain yield (kg per ha)	Fodder yield (kg per ha)	Days to maturity	No. of pods per plant	100 seed weight (g)	Plant height (cm)
TGx 1987-10F	1916	1489	86	88	12.64	38
TGx 1987-62F	1767	1368	82	75	11.05	37
TGx 1835-10E	1627	1334	78	72	13.36	32
TGx 1485-1D	1551	1316	79	66	11.82	30
NCRI Soy8	1474	1304	106	61	10.02	40
TGx 1448-2E	1905	1517	101	117	12.60	40
Mean	1707	1388	89	80	11.91	36
CV (%)	13	14	14	14	15.70	14
SE	5	4	6	7	0.16	3

Varieties released

TGx 1835-10E was the first variety to be released in Nigeria in 2008, in one season PVS trials, due to its superior performance, particularly rust resistance. The Nigerian Plant Variety Release Committee in its meeting in December 2008 approved the registration and release of TGx 1835-10E for general cultivation. This is the first release of a rust-resistant variety in West and Central African countries, as well as the first release of a soybean variety in Nigeria since 1992. In an on-farm trial carried out at 13 locations in eight states, TGx 1835-10E showed a yield advantage of 25% over a rust susceptible variety TGx 1485-1D used for a long time. Subsequently, a new medium maturing variety, TGx 1904-6F, with high grain and fodder yields was released at the end of 2009 in Nigeria. TGx 1904-6F is adapted to northern Nigeria where both crop and livestock farming is practiced. This variety has a high biological nitrogen fixation capacity. TGx 1904-6F is resistant to lodging, pod shattering, *Cercospora* leaf spot and bacterial pustule. In Borno State, the mean grain yield of TGx 1904-6F was 3034 kg per ha whereas the previously popular variety TGx 1448-2E gave 2441 kg per ha. This variety was released in Nigeria by the National Variety Release Committee at its meeting in Ibadan on 4 December 2009. The variety was released based on its performance in northern Nigeria where soybean is gaining faster acceptability. The farmers in Borno and Kano states like this variety because it provides fodder for their animals during the dry season in addition to its high grain yield.

Another two rust resistant varieties (TGx 1987-62F and TGx 1987-10F) were released in Nigeria through the approval of the Nigerian Variety Release Committee in December 2010. TGx 1987-62F and TGx 1987-10F gave an average grain yield of 1670 and 1630 kg per ha, respectively, in a two-year multi-location on-station trials in Nigeria. TGx 1987-62F and TGx 1987-10F gave 58% and 54% more grain yield, respectively, as compared to an early maturing variety TGx 1485-1D in a two-year average performance. They also surpassed the recently released variety TGx 1835-10E by 22% to 33% in grain yield in the 2009 on-station trials. These varieties mature in 96-97 days on average and are capable of producing 2.6 MT per ha fodder under on-station trials condition. Besides giving high grain yield, these varieties were resistant to soybean rust and other foliar diseases. In the 2009 multi-location trials, rust incidence was only 1.3-1.6% as compared to the susceptible variety TGx 1485-1D that showed a 22.3% incidence in the same trial. On-farm trials in four states (Kaduna, Benue, Kano and Niger) of Nigeria by 175 farmers showed that TGx 1987-10F and TGx 1987-62F gave 1626 kg per ha and 1567 kg per ha, respectively. These new varieties surpassed TGx 1485-1D by 5 - 9% in terms of grain yield. These varieties are preferred by many farmers because they smoother weeds and reduce the cost of weeding, mature early, give high yield and the seed colors are attractive.

In Malawi, TGx 1740-2F was officially released on 18 January 2011 through the approval of the Malawi Agricultural Technology Clearing Committee (ATCC). TGx 1740-2F outperformed the popular varieties being grown in the country during both on-station and on-farm trials. It has proven to be a promising variety giving high grain yields in multiple locations under on-station and on-farm trials, its capacity to nodulate under natural field conditions, and its ability to mature early. During the two-year multi-location on-station trials conducted in Malawi, the promiscuous variety gave the highest mean grain yield of 2464 kg per ha. It exceeded the grain variety *Nasoko* and the widely grown promiscuous variety *Magoye*, which were used as checks, by 10% and 32%, respectively. This variety performed equally well during on-farm PVS in four districts of central Malawi. In 2009/10 season, it out-yielded all the new types of soybean varieties under testing with the average yield of 2248 kg per ha. It also surpassed *Nasoko* and *Magoye* by 15% and 38%, respectively. The farmers had many reasons for liking it — it matures early, has more pods per plant, performs well under poor and erratic rainfall, and has better lodging resistance. It received the name '*Tikolore*' (let us harvest) by farmers.

In Kenya five soybean varieties (Nyala, Hill, Black Hawk, Gazelle, and EAI 3600) that have been used in the country for a long time were officially released and registered in April 2009 by KEPHIS. In June 2010, two dual-purpose promiscuous varieties (TGx 1740-2F and TGx 1895-33F) were released (Table 11-15). TGx 1740-2F was found to be high yielding (6.5% over the mean of checks), high biomass (1.5 - 3 MT per ha), rust tolerant, nodulates with indigenous populations of rhizobia in western Kenya, has high pod clearance (13.2 cm) and high pod load, and good for making soymilk. TGx 1895-33F also showed high yield (7.7% over the mean of checks), high biomass (2.5 - 3 MT per ha), promiscuous nodulation, high pod clearance (9.1 cm), high pod load, cream yellow seed color, large seed size and good for making soymilk.

Five candidate lines, namely, TGx 1740-2F (Wanini), TGx 1908-8F (Wima), TGx 1904-6F (Zamboane), TGx 1937-1F (Olima), TGx 1485-1D (Sana) were submitted for registration and released in Mozambique. This is the first time Mozambique has officially released soybean varieties.

Soybean Breeder's Seed production

In Malawi, a total of 22.5 MT of Breeder's Seed was produced in 2008-2010 from five varieties (Table 11-16). This seed went into foundation seed production. Seeds produced from elite breeding lines were used for experimental purposes both on-station and on-farm. Similarly, in Mozambique, 29T of Breeder's Seed was produced over three years from more than half a dozen candidate varieties. In Nigeria the total amount over three years was 3.2 MT from nine varieties. In Kenya 8.5 MT of Breeder's Seed was produced. Overall, the total amount of Breeder's Seed produced from soybean across project countries and years amounted to 64 MT.

Elite materials shared with NARS

A total of 357 soybean genotypes were shared among partners in the past three years (Table 11-17. These materials included the ones used for fast-tracking testing where varieties were released and new lines developed with resistance to rust. Tests on these new breeding lines in Malawi at four locations (Chitedze, Mbawa, Chitala and Makoka) in 2009/10 showed that significant differences for grain yield among genotypes were observed at Chitala and Makoka (Table 11-18). However, no significant differences were observed at Chitedze and Mbawa. Higher average yield was obtained at Chitedze Research Station (2250 kg per ha), followed by Chitala (1656 kg per ha). TGx 1987-62F was the highest yielder across sites (2144 kg per ha). At Chitedze Research Station, TGx 1987-10F out-yielded all the tested lines with a grain yield amounting to 3274 kg per ha, followed by TGx 1987-62F (2919 kg per ha). At Makoka, TGx 1987-64F was the best performer with a grain yield of 1408 kg per ha, followed by TGx 1987-62F (1389 kg per ha). These are the only two lines which out-yielded the control Magoye (1161 kg per ha). TGx 1805-31F (3264 kg per ha) and TGx 1485-1D (2458 kg per ha) yielded higher than the rest of the tested lines at Mbawa Research Station while at Chitala TGx 1485-1D and TGx 1987-18F had higher yields of 2228 and 2211 kg per ha, respectively.

Table 11-15: Release notes of the two soybean varieties released in Kenya - 2010

<table>
<tr><th>Tested in NPT as</th><th>Name</th><th>Proposed official name for release</th><th>Year of release</th><th>Owner</th><th>Maintainer and seed source</th><th>Optimal production altitude range (masl)</th><th>Duration to maturity (months)</th><th>Grain yield (MT per ha)</th></tr>
<tr><td rowspan="2">SB19</td><td>TGx 1740-2F</td><td>DPSB 19</td><td>2010</td><td>IITA</td><td>KARI/ Leldet seed company</td><td>900 -2400</td><td>3-4</td><td>0.6 - 1.7</td></tr>
<tr><td colspan="8">Special attributes:
• Dual purpose (high biomass, high yield and free nodulating)
• High yield , 6.53% over the mean of checks; high biomass (1.5-3.0 MT per ha)
• Rust resistant
• Nodulates with indigenous population of rhizobia in Kenya soils to fix atmospheric nitrogen
• Good for making soyabean milk
• High pod clearance (13.2 cm), hence easy to harvest using combine harvester, if necessary
• High pod load (28 pods per plant)
• Attractive creamy seed coat
• Good for intercropping
• Medium seed size</td></tr>
<tr><td rowspan="2">SB8</td><td>TGx 1895-33F</td><td>DPSB 8</td><td>2010</td><td>IITA</td><td>KARI / Leldet seed company</td><td>900 -2400</td><td>4-5</td><td>0.5 -2.6</td></tr>
<tr><td colspan="8">Special attributes:
• Dual purpose (high biomass, high yield and free nodulating)
• High yield , 7.71 % over the mean of checks; - High biomass (2.5-3.0 t/ha)
• Nodulates with indigenous population of rhizobia in Kenya soils to fix atmospheric nitrogen
• Good for making soyabean milk
• High pod clearance (9.1 cm) hence easy to harvest using combine harvester, if necessary.
• High pod load 33 pods per plant
• Attractive creamy seed coat
• Good for monocropping
• Large seed size</td></tr>
</table>

In Mozambique, significant differences were obtained among the new lines in the 2009/10 multilocation trials at Ruace, Nampula and Domue (Table 11-19). Average location yield at Ruace was 4031 kg per ha whilst it was 1407 kg per ha and 1692 kg per ha at Nampula and Domue, respectively. At Ruace, the top grain yield of 4960 kg per ha was obtained from TGx 1485-1D, followed by TGx 1972-1F with 4930 kg per ha. The check variety (Storm) gave 4159 kg per ha. In general, Ruace is a high potential area for soybean cultivation as yields of all the test genotypes ranged from 3154 kg per ha to 4960 kg per ha. At Nampula the highest yield of 2037 kg per ha was obtained from TGx 1937-1F, followed by TGx 1987-38F with 1994 kg per ha whereas the check variety Storm gave a grain yield of 971 kg per ha, which was the second highest yield from the bottom. At Domue (Tete province), TGx 1987-38F gave the highest grain yield of 2475 kg per ha, followed by TGx 1987-62F (2465 kg per ha). At this location the yield of Storm was the lowest (668 kg per ha). Across locations, the best performers were TGx 1987-38F, TGx 1987-20F and TGx 1987-62Fwhereas Storm was the least performer as compared to the test genotypes.

In western Kenya, the new breeding lines showed excellent performance in 2010 (Table 11-20). Significant differences among lines were obtained from Sidada and Kokare sites. Location mean yields were higher at Sidada (2785 kg per ha) as compared to Kokare (1003 kg per ha). All the new breeding lines surpassed the local check (Nyala) at Sidada. The top yielders were TGx 1987-18F (3287 kg per ha), TGx 1987-20F (3200 kg per ha) and TGx 1987-65F (3167 kg per ha). At Kokare, TGx 1987-18F, TGx 1987-32F and TGx 1987-20F were top yielders with a respective yields of 1963 kg per ha, 1856 kg per ha, and 1845 kg per ha. These new breeding lines also showed resistance to rust at these locations.

Table 11-16: Soybean Breeder's Seed produced (MT) from different varieties in the project countries, 2007/08 – 2009/10

Variety	2008	2009	2010	Total
Malawi				
Nasoko	0.300	3.980	5.181	9.461
Ocepara-4	0.500	1.250	0.852	2.602
Magoye	0.100	0.510	0.128	0.738
Makwacha		4.110	4.131	8.241
TGx 1740-2F			0.060	0.060
Breeding lines			1.411	1.411
Malawi total	**0.900**	**9.850**	**11.763**	**22.513**
Mozambique				
TGx 1908-8F		2.991	3.400	6.391
TGx 1937-1F		2.145	2.300	4.445
TGx 1904-6F		1.644	2.875	4.519
TGx 1740-2F		2.158	3.450	5.608
TGx 1485-1D		1.381	0.850	2.231
TGx 1835-10E		0.157	1.200	1.357
TGx 1910-14F		0.911		0.911
TGx 1951-3F		0.056	0.850	0.906
TGx 1972-1F			0.950	0.950
TGx 1963-3F			0.900	0.900
Breeding lines	0.600	0.900		1.500
Mozambique total	**0.600**	**12.343**	**16.775**	**29.718**
Nigeria				
TGx 1440-1E	0.100	0.003		0.103
TGx 1448-2E	0.111	0.012		0.123
TGx 1019-2EB	0.005	0.015		0.020
TGx 1835-10E		0.159	0.040	0.199
TGx 1485-1D		0.006		0.006
TGx 1904-6F		0.004	0.100	0.104
TGx 1019-2EN		0.002		0.002
TGx 1987-10F		0.334	0.050	0.384
TGx 1987-62F		0.112	0.050	0.162
Breeding lines	0.502	0.693	0.888	2.083
Nigeria total	**0.718**	**1.34**	**1.128**	**3.186**
Kenya				
Namsoy 4m		0.300	0.906	1.206
TGx 1835-10E		0.300	1.714	2.014
TGx 1740-2F		0.310	2.116	2.426
TGx 1895-33F			0.063	0.063
Maksoy-1a			0.311	0.311
Nyala			0.182	0.182
Gazelle			0.264	0.264
Breeding lines			2.035	2.035
Kenya total	**0.000**	**0.910**	**7.591**	**8.501**
Overall total	**2.218**	**24.443**	**37.257**	**63.918**

In Nigeria, across locations mean performance data for grain yield of rust resistant lines is presented in Table 11-21. TGx 1987-62F and TGx 1987-10F gave an average grain yield of 1841 and 1719 kg per ha, respectively, in three-year multi-location on-station trials. TGx 1987-62F and TGx 1987-10F gave a respective 50% and 40% more grain yield as compared to an early maturing variety TGx 1485-1D in a three-year average performance. They also surpassed the recently released variety TGx 1835-10E by 33% to 41% in grain yield in the 2009 and 2010 on-station trials. These varieties mature in 96-97 days on average and are capable of producing 2.6 MT per ha fodder under on-station trials condition. Besides giving high grain yields, these varieties were found to be resistant to soybean rust and other foliar diseases. In the 2009 and 2010 trials, rust incidence in these varieties was only 0.2-0.5%, as compared to the susceptible variety TGx 1485-1D that showed a 61% incidence in the same trial (Table 11-22).

Table 11.17: Number of soybean varieties and elite lines distributed to NARS

Country	Institute	2007	2008	2009	Total
Malawi	DARS	60			60
Mozambique	IITA-Mozambique	20	58	60	138
Nigeria	NCRI	20	6	20	46
Kenya	TSBF-CIAT	21		19	40
Kenya	KARI			19	19
Kenya	Leldet	9			9
Tanzania	ARI-Ilonga	25			25
Ethiopia	EIAR		20		20
Total		**155**	**84**	**118**	**357**

Table 11-18: Mean grain yield (kg per ha) of soybean genotypes in advanced variety trial early set at four locations in Malawi - 2009/10 growing season

Genotype	Chitedze	Chitala	Makoka	Mbawa	Mean
TGx 1987-62F	2919	1906	1389	2361	2144
TGx 1805-31F	2724	1878	532	3264	2099
TGx 1987-64F	2467	2189	1408	1500	1891
TGx 1485-1D	2077	2228	726	2458	1872
Magoye	2190	2194	928	1694	1752
TGx 1987-11F	2571	1517	858	2014	1740
TGx 1987-10F	3274	1600	847	972	1673
TGx 1987-18F	2204	2212	818	1251	1621
TGx 1987-65F	2228	1794	1096	1208	1582
TGx 1987-23F	2028	1733	541	1806	1527
TGx 1987-6F	2605	1211	1056	1069	1485
TGx 1987-34F	1891	1522	669	1736	1455
TGx 1987-31F	2338	1467	874	1125	1451
TGx 1987-9F	1691	1994	824	1264	1443
TGx 1987-17F	2210	1239	866	1361	1419
TGx 1987-25F	2220	1511	706	1236	1418
TGx 1987-8F	2086	1794	897	862	1410
TGx 1987-20F	2142	1217	573	1611	1386
Nasoko	2274	950	912	1333	1367
UG 5	1833	1167	1161	1264	1356
TGx 1987-32F	2076	1544	602	1111	1333
TGx 1987-28F	1454	1567	647	1333	1250
Mean (22 lines)	2250	1656	860	1538	1576
SE	346	229	179	458	161
LSD (0.05)	NS	654	511	NS	449

Table 11-19: Grain yield (kg per ha) of elite soybean genotypes and rust-tolerant lines evaluated during the 2009/10 growing season at three locations in Mozambique

Genotype	Location		
	Ruace	Nampula	Domue
TGx 1908-8F	3965	1146	1696
TGx 1937-1F	4498	2037	1180
TGx 1904-6F	3514	1545	1542
TGx 1740-2F	3154	1200	1459
TGx 1485-1D	4960	1052	1755
TGx 1835-10E	3917	1172	1784
TGx 1951-3F	4245	906	1887
TGx 1972-1F	4930	1268	879
TGx 1963-3F	3436	1606	2081
TGx 1932-1F	3436	1564	1677
TGx-1987-20F	4789	1749	2247
TGx-1987-38F	4630	1994	2475
TGx-1835-10E	3917	1172	1784
TGx-1987-62F	3795	1678	2465
TGx-1987-65F	3157	1445	1497
Storm	4159	971	668
LSD (0.05)	1237	875	501
CV (%)	22	45	21

Table 11-20: Grain yield (kg per ha) of new breeding lines at Sidada and Kokare, western Kenya - 2010 growing season

Genotype	**Sidada**	**Kokare**	**Mean**
TGx 1987-18F	3287	1963	2625
TGx 1987-20F	3200	1845	2522
TGx 1987-65F	3167	1279	2223
TGx 1987-6F	3110	1263	2186
TGx 1987-9F	3188	1041	2115
TGx 1987-32F	2326	1856	2091
TGx 1987-11F	3051	1045	2048
TGx 1987-62F	2477	1373	1925
TGx 1987-17F	3198	647	1922
TGx 1987-64F	3039	793	1916
TGx 1987-34F	2895	918	1906
TGx 1740-2F	2723	958	1841
TGx 1987-25F	3163	395	1779
TGx 1987-23F	2922	558	1740
TGx 1987-28F	2963	513	1738
TGx 1987-10F	2739	635	1687
TGx 1987-8F	2724	621	1672
TGx 1987-31F	2407	476	1441
TGx 1835-10E	1794	1022	1408
Nyala	1337	859	1098
Mean	2785	1003	1894
SE	243	329	205
CV (%)	15	57	26
P	<.0001	0.0298	0.0002
LSD (0.05)	696	942	576

Table 11-21: Grain yield (kg per ha) performance of TGx 1987-62F and TGx 1987-10F in multilocation trials for three years in comparison with check varieties in Nigeria

Variety	2008	2009	2010	Mean	% increase over TGx 1835-10E	% increase over TGx 1485-1D
TGx 1987-62F	2241	1334	1946	1841	41	50
TGx 1987-10F	2161	1225	1770	1719	32	40
TGx 1835-10E		1005	1599	1302		
TGx 1485-1D	1699	574	1412	1228		
Trial mean	1891	1126.4	1892.5	1637		
Se	92	142.2	128.5			
P (Variety)	0.0001	0.0000	0.0001			

2008, 2009 and 2010 trials comprised 20, 22 and 20 test genotypes, respectively, and the number of locations in each year ranged from three to five.

Table 11-22: Rust severity (%) on TGx 1987-62F and TGx 1987-10F at Ibadan (rust hotspot), Nigeria, in 2009 and 2010 in comparison with check varieties

Variety	2009	2010	Mean
TGx 1987-62F	0.6	0.4	0.5
TGx 1987-10F	0.3	0.1	0.2
TGx 1835-10E	14.1	11.0	12.5
TGx 1485-1D	63.8	59.1	61.4
Trial mean	8.4	3.8	6.1
SE	3.5	2.1	
P	0.0000	0.0001	

Segregating materials generated

Based on previous work and current project activities, a total of 24 soybean parental lines have been identified for crossing work to generate segregating populations. The work is aimed at recombining several desirable traits that included promiscuity, high yield, high biomass, earliness, rust tolerance, drought tolerance and adaptation to the southern Africa conditions. At Chitedze, Malawi, segregating populations of F_2 and F3 generations were grown to select for adaptation, earliness, disease resistance, high biomass and pod load in the 2009/10 season. High shoot biomass is an indicator of enhanced biological nitrogen fixation as the plots did not receive nitrogenous fertilizers. A total of 33 individual plants were selected for these desirable traits from the F_2 crosses. From the F_3 a total of 1099 individual plants were selected. F_1 plants were also raised in the screen house from 18 crosses and their F_2 seeds were harvested.

At IITA-Ibadan station, a total of 378 F_3 family rows were raised in 2009 from 33 crosses and a total of 485 individual plants were selected for their rust and other leaf diseases resistance, vigorous biomass and pod load (Table 11-23). Similarly, 130 F_5 family rows were grown at the same location and 183 desirable plants in terms of disease resistance, vigor and pod load were selected (Table 11-24). A total of 21 new crosses were also made from selected parental lines. Recombinant inbred lines (RILs) from two crosses were also raised for phenotyping. From TGx 1485-1D × UG5 and TGx 1485-1D × Soy104, a total of 299 and 287 RILs, respectively, were phenotyped for disease resistance and other associated traits. The F4 and F6 families of the selected plants were also grown in 2010.

Table 11-23: F3 Segregating populations grown and individual plants selected at Ibadan in 2009 main season

No.	Cross	No. of family rows grown	No. of plants selected*
1	TGx 1987-14F x MW1	7	16
2	TGx 1740-2 x MW1	9	12
3	TGm 1179 x MW1	4	0
4	TGm 1082 x MW1	9	14
5	TGx 1830-20E x UG5	21	29
6	TGx 1830-20E x TGx 1740-2F	11	4
7	TGx 1983-1F x SOY104	6	9
8	TGx 1983-1F x UG5	12	19
9	TGx 1983-1F x TGx 1835-10E	14	15
10	TGx 1983-1F x TGx 1740-2F	13	4
11	TGx 1830-20E x TGx 1835-10E	11	14
12	TGx 1835-10E x UG5	13	24
13	TGx 1954-1F x UG5	13	31
14	TGx 1954-1F x SOY104	14	21
15	TGx 1830-20E x SOY104	13	16
16	UG5 x SOY104	13	16
17	TGx 1740-2F x SOY104	14	22
18	TGx 1740-2F x UG5	13	35
19	TGx 1954-1F x TGx 1835-10E	12	8
20	TGx 1954-1F x TGx 1740-2F	13	5
21	TGx 1835-10E x TGx 1740-2F	14	20
22	TGx 1835-10E x SOY104	14	18
23	TGx 1987-14F x TGx 1740-2F	31	38
24	TGx 1987-37F x TGx 1740-2F	24	28
25	TGx 1835-10E x TGm 1179	15	17
26	TGx 1987-14F x TGm 1082	5	13
27	TGx 1987-37F x TGm 1082	8	9
28	UG5 x TGm 1179	4	3
29	UG5 x TGm 1082	7	6
30	TGx 1835-10E x TGm 1082	6	6
31	TGx 1987-37F x TGm 1179	4	8
32	TGx 1830-20E x TGm 1082	4	0
33	TGx 1954-1F x TGm 1082	7	5
Total		**378**	**485**

**Mainly for rust*

Table 11-24: F_5 segregating populations grown and plants selected at Ibadan in the 2009 main season

Cross	No. of family rows grown	No. of plants selected*
TGx 1740-2F x SOY104	11	16
TGx 1440-1E x SOY104	19	35
TGx 1448-2E x SOY104	11	8
TGx 1485-1D x SOY104	3	12
TGx 1740-2F x UG5 x SOY104	14	2
TGx 1440-1E x UG5 x SOY104	14	28
TGx 1448-2E x UG5 x SOY104	9	9
TGx 1485-1D x UG5 x SOY104	13	5
TGx 1440-1E x UG5	12	25
TGx 1448-2E x UG5	13	38
UG5 x SOY104	11	5
Total (11 crosses)	**130**	**183**

**Mainly for rust*

Progress in selection of *Bradyrhizobium* strains

At IITA-Ibadan, four soybean genotypes (TGx 1448-2E, TGx 1485-1D, TGx 1838-5E, and TGx 1906-3F) were inoculated with 20 *Bradyrhizobium* strains in 2008. One milliliter portions of broth cultures were used to inoculate each of six seedlings of the four genotypes grown in beach sand with regular supply of plant nutrient solution. The controls were plus N (70 ppm) and non-inoculated control (minus *Rhizobium* and minus N). Plant cultures were maintained in the greenhouse for 10 weeks (10 June to 19 August 2008). Soybean genotypes inoculated with *Bradyrhizobium* strain RAUG1 and RAUG2 had the highest shoot nitrogen concentration and these figures were significantly higher than that of soybean genotypes inoculated with the other strains (Table 11-25). It is important to state that the lower shoot nitrogen concentration reported for some of the genotypes might have been due to dilution effect associated with larger shoot biomass compared to that of soybean genotypes inoculated with RAUG1 and RAUG2. The high performing *Bradyrhizobium* strains have been multiplied and the inocula tested on many more soybean genotypes under field conditions.

Table 11-25: Shoot dry weight and nitrogen concentration in the shoot of four soybean genotypes inoculated with 20 *Bradyrhizobium* strains at IITA-Ibadan.

Bradyrhizobium strain	Shoot dry weight (g)					Nitrogen concentration in shoot (%)				
	G1	G2	G3	G4	Means	G1	G2	G3	G4	Means
RAUG1	19.493	19.443	4.973	5.180	12.272	3.883	4.146	4.013	4.141	4.046
RAUG2	18.487	18.873	6.253	4.387	12.000	4.187	4.139	3.972	3.75	4.012
RACA2	17.273	16.377	6.177	7.310	11.784	3.687	3.499	3.607	3.524	3.579
Irj 2180A	13.133	10.733	13.08	9.697	11.661	3.612	3.970	2.925	3.276	3.446
RACA4	14.033	14.637	8.663	8.077	11.353	3.795	3.496	3.306	3.661	3.565
RACA6	13.807	16.037	8.043	7.490	11.344	3.735	3.426	3.712	3.743	3.654
RACA3	15.330	15.85	6.790	7.183	11.288	3.557	3.638	3.413	3.845	3.613
R.25B	11.610	11.523	9.700	7.883	10.179	3.480	3.781	2.838	3.539	3.410
S(3)PEAT	9.653	6.687	9.487	11.760	9.397	2.673	3.334	3.272	3.317	3.149
RANI 22	7.053	7.830	9.163	6.500	7.637	3.435	3.602	3.211	3.059	3.327
FA3	11.103	6.100	6.650	6.560	7.603	3.641	3.807	3.416	3.417	3.570
TAL169	10.200	8.407	6.577	4.650	7.458	3.778	3.929	2.928	3.536	3.543
USAD4671	9.390	8.157	2.813	8.973	7.333	2.919	2.802	2.028	2.875	2.656
S(I)PEAT	7.083	6.337	6.700	7.613	6.933	3.683	3.818	3.298	3.237	3.509
R.58	10.297	4.007	0.950	7.380	5.658	2.676	2.604	0.927	2.499	2.177
N+ (control)	4.607	5.133	5.300	6.040	5.270	1.290	1.648	1.089	1.310	1.334
MRCP1	1.840	6.893	0.850	10.730	5.078	1.281	2.832	1.326	2.992	2.108
R.31B	2.300	0.913	0.563	11.720	3.874	2.421	1.399	1.029	1.976	1.706
RATG9	1.810	1.637	0.650	5.870	2.492	1.498	1.424	0.997	2.159	1.519
N- (control)	3.287	1.367	1.157	3.087	2.224	1.238	1.127	1.039	1.413	1.204
R.59	1.470	0.817	0.937	2.383	1.402	1.195	1.546	1.364	1.287	1.348
Means	9.679	8.941	5.499	7.165		2.936	3.046	2.558	2.979	
SE (G)	0.360					0.050				
SE (B)	0.820					0.120				
SE (G x B)	1.640					0.240				
P (G)	≤ 0.0001					≤ 0.0001				
P (B)	≤ 0.0001					≤ 0.0001				
P (G x B)	≤ 0.0001					≤ 0.0001				
CV (%)	36.210					16.640				

G1= TGx 1906-3F, G2= TGx1484-1D, G3= TGx1448-2E, G4= TGx1835-5E

G = Genotype, B = *Bradyrhizobium* strain, G x B= Genotype × *Bradyrhizobium* strain

At TSBF-CIAT in Kenya, a study was conducted to assess the nodulation and nitrogen fixation of a set of nine indigenous *Bradyrhizobium* strains inoculated on three promiscuous soybean varieties grown under greenhouse conditions. Seedlings of three promiscuous soybean varieties (TGx 1895-33F, TGx 1895-49F and TGx 1740-2F) were each inoculated with 3 ml each (10^8 cell mL^{-1}) of pure indigenous *Bradyrhizobium* strains (TSBF 404, TSBF 101, TSBF 131, TSBF 531, TSBF 534, TSBF 331, TSBF 442, TSBF 344, TSBF 3360). Negative and positive (98 kg per ha N equivalent) controls were also included. The seedlings were grown in 2 kg sand filled polybags, kept at field capacity by alternate day watering with double distilled water and Broughton solution in a greenhouse at approximately 12/12 light and 25 °C/32 °C. Seedlings were harvested at R1 growth stage for each of the genotypes and nodule number and shoot biomass recorded. All samples were dried to constant weight for 48 hrs at 70 °C. Shoot dry weight (SDW) was recorded as it is used as proxy for nitrogen fixation. There was no interaction between strains and varieties on shoot dry weight (Figure 11-4).

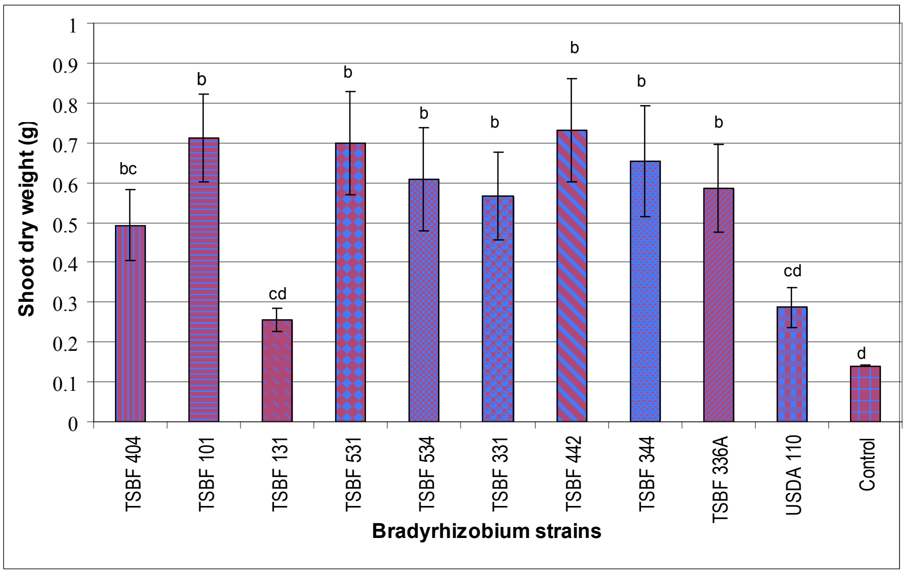


Figure 11-Shoot dry weight of three promiscuous soybean varieties grown in sand under greenhouse conditions

However, there was a highly significant (P<0.001) difference among strains on shoot dry weight. Shoot weight ranged from 0.138 g per plant for negative control to 0.731 g per plant for TSBF 442 strain. TSBF 442 had more than five times more shoot dry biomass than the negative control while it recorded 2.5 times more shoot biomass than the control strain (USDA 110). The control strain USDA 110 produced significantly less dry shoot biomass and nodules than all tested strains in all three varieties. All varieties fixed significantly higher amounts of nitrogen when inoculated with all indigenous strains but TSBF 131.

Progress in soybean recipe development

A number of soybean-based recipes were introduced in the project areas during training of trainers and subsequent trainings by trained groups. In Malawi, 15 recipes were developed and introduced to project sites. These include Flour from boiled soybeans, Bread/*chikondamoyo,* Soy mince, Soya porridge, Soya *nsima,* Soya-cassava *nsima,* Soya snack candy (*suwiti za soya*), Soya snack/*chiponde cha soya,* Soya-cassava doughnuts, Soya Jollof Rice, Soybean vegetable soup/*masamba wotendera ndi soya, Usipa wotendera ndi soya, Zitumbuwa,* Soya-cassava porridge, and Soya milk. Twelve recipes introduced in the project areas`of Kenya were soybean milk, soybean nuts, soybean balls, okara sausages, soybean omushenye, soybean vegetable mix, *wimbi* and corn porridge, soybean puff, soybean *chin chin*, soybean *mandazi*, soybean chapatti, and soybean wheat bread. A total of 15 recipes were introduced in project sites of Nigeria. These recipes are soymilk, soy tofu, soy tofu stick, scramble tofu, weaning food, *soy akamu*, *soy kunnu zaki*, *soy kunnu gyda*, *soy akara*, *soy chinchin*, soy buns, *soy waina rogo* (fried grated cassava with spices), *soy gari*, *soy kawakawa*, and soy flour. In Mozambique, eight recipes aimed at enhancing the protein and energy quality of the most common foods were introduced within the major soybean producing localities: Ruace, Murrimo, Magige, Lioma and Tetete in Gurue district in Zambesia province. The recipes being promoted include: a) Soy milk, b) Soy fortified thin and thick porridge, c) Tomato Soybean relish, d) Soy-vegetable soup, e) Rice-soy mix, f) Soybean nuts, g) Soy-wheat flour bread, and h) Soy-wheat flour cake.

Capacity building

Degree training

The list of postgraduate students under soybean is presented in Table 11-26. The graduate student, Mr. Justine A. Mushi who has been studying at the Sokoine University of Agriculture for his MSc degree in agricultural engineering with emphasis on soybean processing has successfully finished his course work. He is expected to submit his thesis work in December 2011. The main objective of his study is to investigate how the de-hulling efficiency of abrasive mechanical de-hullers and how the quality of dehulled soybean products could be improved. Mr. Shaahu Aoondover, who has been doing his MSc training on soybean breeding at University of Agriculture Makurdi, is writing his thesis to complete his study. Anica Massas of Mozambique has completed her MSc study in soybean breeding at Bunda College, University of Malawi. The study of Mr. David Nyongesa is still ongoing.

Table 11-26: Postgraduate students from project countries in different aspects of soybean under TL II project

Name	Country	Degree	University	Research Project	Status
Mr. Justine Mushi	Tanzania	MSc	Sokoine Univ. of Agric.	Processing and utilization	Ongoing
Mr. David Nyongesa	Kenya	PhD	Univ. of Dar es Salaam	Soybean value chains	Ongoing
Ms. Anica Massas	Mozambique	MSc	Univ. of Malawi, Bunda College	Soybean breeding	Completed
Mr. Aoondever Shaahu	Nigeria	MSc	Univ. of Makurdi	Soybean breeding	Ongoing

Progress in training farming communities

A number of training activities were carried out in the project countries with respect to soybean production, participatory variety selection, processing and utilization and marketing. A number of existing training materials have been modified and translated in to the local languages to improve usage. From 2007 to 2010 a total of 14,223 farmers were trained across the project countries (Table 11-27). The training included soybean crop handling and production, participatory variety selection, marketing, processing and utilization. Large numbers of farmers were trained on processing and utilization. Female trainees constitute the majority (62%).

Table 11-27: Training of farmers on soybean production, PVS, marketing, processing and utilization in five target countries, 2007/08 – 2009/10

Country	2007/08		2008/09		2009/10		Total	
	Women	Men	Women	Men	Women	Men	Women	Men
Malawi	51	62	822	668	838	393	1711	1123
Mozambique	137	328	1336	616	1298	812	2771	1756
Nigeria	633	2	845	431	581	22	2059	455
Kenya	53	146	432	600	732	300	1217	1046
Tanzania	32	68	399	315	639	632	1070	1015
Total	906	606	3834	2630	4088	2159	8828	5395

Grand total: 14,223

Number of NARS scientists trained

Three staff in Malawi and one staff in Nigeria (all men) were trained how to emasculate and pollinate soybean

Number of extension staff trained

From 2007 to 2010 a total of 167 extension staff (including development agents and NGO workers) across the project countries were trained on soybean production, PVS, marketing, processing and utilization. Of these, 32 were women (Table 11-28).

Table 11-28: Extension staff training on soybean production, PVS, marketing, processing and utilization in five countries (2007/08 – 2009/10)

Country	2007/08		2008/09		2009/10		Total	
	Women	Men	Women	Men	Women	Men	Women	Men
Malawi		12	3	12		14	3	38
Mozambique	17	44			12	23	29	67
Nigeria						30	0	30
Kenya							0	0
Tanzania							0	0
Total	**17**	**56**	**3**	**12**	**12**	**67**	**32**	**135**

Grand total: 167

Workshop on *Rhizobium* inoculum

The Soybean *Rhizobium* Inoculum Workshop was held on 17-21 March 2008, at Impala Hotel, Arusha, Tanzania. The main output of the workshop was the production of a document entitled 'Investment Options for Adoption of Biological Nitrogen Fixation (BNF) in Soybean in Sub-Saharan Africa'. This document has been submitted to B&MGF. This document led to the development of a bigger project that included several legumes under the title "Putting Nitrogen Fixation to Work for Smallhoder Farmers in Africa (N2Africa)", which has started to be implemented since 2009.

Vision for Phase 2

Our vision for the second phase in relation to objective 7 is to increase soybean production by 15% through increasing on-farm yields by 20% on 60% of the project target area. With respect to developing improved soybean lines, we aim to evaluate 15 new lines for their drought tolerance and biological nitrogen fixation, evaluate best *Rhizobium* strains in at least 20 best lines, evaluate at least 10 rust resistant lines multilocation and on-farm PVS; select new breeding lines for drought and rust tolerance from more than 30 segregating populations and establish homozygous lines for multilocation testing. We also have the vision to release at least two varieties and produce 10-30 kg breeder's seed every year from each variety developed so far. In order to speed up our work, we will exchange soybean germpalsm and inoculants with N2Africa project. Because much of the soybean produced by farmers is for market, we will assess the protein and oil quality of existing and newly developed varieties and lines. In terms of capacity building, we envision to train at least 15,000 farmers in soybean processing and utilization, and establish at least four more soybean resource centers. We also aim to train five postgraduate students at MSc level in plant breeding and 1,000 farmers, extension staff and technicians in soybean production, PVS and soybean rust.

Seed Production and Delivery Systems

Summary

Soybean is among the major industrial and food crops grown on every continent. The crop can be successfully grown in many areas using low agricultural inputs. Soybean cultivation in Africa has expanded as a result of its nutritive and economic importance and diverse domestic usage. It is also a prime source of vegetable oil in the international market. Soybean has an average protein content of 40% and is more protein-rich than any of the common vegetable or animal food sources found in the world. Soybean seeds also contain about 20% oil on a dry matter basis, and this is 85% unsaturated and cholesterol-free. Generally, soybean is emerging as an important feed, food as well as raw material for producing high-quality protein products, which is currently grown on 1.5 million ha in Africa. In the last five years, soybean area has been increasing at an average of 5% per year whilst total production has been increasing at a rate of 7% per year in Africa. Such an increase has not been sufficient to satisfy the demand for soybean on the continent. Africa imports soybean grain and its products worth about one billion dollars every year. Hence, emphasis should be given to this crop to increase its productivity and production in Africa and narrow the gap between demand and supply.

Soybean production is constrained by unavailability of improved varieties. A number of improved high-yielding soybean varieties have been developed but these have not reached many farmers. The major impediments in soybean adoption in Sub-Saharan Africa are lack of awareness on processing and utilization, low yield, lack of market linkage with processors and consumers, weak policy support, lack of high quality seed, and low product prices. This project is making efforts to address these issues based on the experience of IITA in West Africa and that of TSBF-CIAT in western Kenya. It is believed that soybean production will increase as more farmers become aware of the potential of the crop through enhanced seed delivery systems.

The activities in this project are focused on soybean value chain system to enhance the adoption and use of improved varieties by farmers.

The project goal was to improve sustainability of soybean seed production and delivery systems that will reach the smallholder farmers in drought-prone areas of Sub-Saharan Africa through interventions designed to:

- Facilitate Foundation Seed production;
- Facilitate Certified Seed production;
- Promote and strengthen seed/input marketing through linkages to private seed companies;
- Create awareness to popularize improved stress-tolerant soybean varieties; and
- Build capacity of stakeholders for implementation of the activities.

Increased seed production

By the completion of Phase 1, the project directly supported a total of 1,856 farmers which included both men and women that were involved in on-farm demonstrations to popularize improved soybean varieties in the participating countries. Field observations have shown widespread adoption of new varieties of soybean, a substantial increase in yields, as well as an increase in food security and reduction in poverty. Farmers have reported that problems relating to access to improved seed, low soil fertility and *Striga* infestation were being solved, but would require continued support to ensure such problems do not recur. Problems of input availability, especially fertilizer, although addressed still remain but require improved policies to address farmer concerns. Livelihoods have improved through better food security and nutrition, reduced poverty, and an increased ability to pay other costs. A strong gender dimension and special support to empower women involved a group of women groups, with special initiatives for soybean processing, value adding, household utilization and marketing to processors.

Improved access to markets

Improved market linkages have encouraged seed producers to improve and increase seed production to supply a growing market. The project has demonstrated that community production of improved varieties can be successful, but its sustainability depends on development of successful seed associations, cooperatives with links to the formal seed sector and market.

Market development for soybean resulted in increased production and sales of soybean making significant contribution to improving livelihood and poverty reduction. This market is now established paying good prices. In the last three years over 405 MT of soybean has been produced by seed producers. Of this amount, 386 MT was sold as a result of market outlet. Similarly, 125 MT of Foundation Seeds have been produced over the last three years.

Awareness creation of improved varieties

Awareness creation to popularize improved varieties through field days, TV, Radio programs and newspaper reports has been carried out. Over the last three years, 34 field days, 10 TV programs, 14 radio programs, and 9 newspaper articles have been held.

Increased capacity of partners

The project, having recognized the significance of capacity building of its partners to achieve its objectives, organized and facilitated capacity development activities for its partners. Their capacities have been strengthened through training and subsequent applications; participation in national and international scientific conferences and meetings; research opportunities for higher degrees based on TL II activities as well as improved access to information and new knowledge.

Strengthening of extension agents and community-based organizations, in particular the farmer groups and associations, through technical training in many aspects of soybean productionreinforced with post-harvest processing, storage, distribution and marketing. Over the last three years 480 extension agents and 4998 farmers have been trained on soybean seed production technology and general agronomic practices in the project countries. Two students were registered for MSc program to read seed technology in Malawi and Niger Republic.

Project administration

The project held a major planning workshop for all collaborators in the project countries to develop action plan for the implantation of the soybean seed systems. Subsequently, each country organized a planning meeting to harmonize their action plan in all the five participating project countries and used to formulate strategies for Foundation Seed production in the project countries. This report details TL II's achievements over the last three years.

Major outputs and outcomes

Progress in Foundation and Certified Seed production

Over the last three years, a total of 125.7 MT of Foundation Seeds of diverse varieties of soybean have been produced for sales to community seed growers in the project countries. Of this quantity, Nigeria produced 23.8 MT, Kenya, produced 38.3 MT, Malawi produced 27.6 MT, and Mozambique produced 36 MT (Table 11-29). All the countries produced in excess of the annual target of 15 MT per year in 2010 except Nigeria.

Table 11-29: Quantity (MT) of Foundation Seed of soybean produced in target countries

Country	Year			Total
	2008	2009	2010	
Kenya	10.0	11.0	17.3	38.3
Malawi	4.0	8.0	15.6	27.6
Mozambique	3.5	11.4	21.1	36.0
Nigeria	8.4	10.3	5.1	23.8
Total	**25.9**	**40.7**	**59.1**	**125.7**

Building and strengthening local partnership

At the commencement of the major activities, the project held a major planning workshop for all collaborators in the project countries to develop action plan for the implantation of the project. Subsequently, each country organized a planning meeting to harmonize and fine tune their project implementation. Thereafter, series of meetings and visits were also made by the project coordinator and other team leaders to ensure compliance of the agreed implementation plan. Consultations were also held among socio-economist in the participating institutions to plan surveys aimed at assessing capacity of NARS/institutions to produce Foundation Seed. During this process, a report on the potential of Foundation Seed production in all the participating project countries were prepared and submitted. In student capacity building, Mr. Guilhermo Boina completed his MSc degree program in Seed Technology at Bunda College of Agriculture, University of Malawi. Mr. Habou Aboubacar in Niger is about to defend his MSc degree program in Seed Technology from the University of Niamey.

Progress in the production of Quality Assured Seed

Considerable progress has been made in the production of Quality Assured/Certified Seed by community-based seed producers and seed companies in the various countries. The project promoted community seed production and linked seed producers to seed companies and agro-processors. The linkage was aimed to encourage the seed producers to improve and expand seed production as a result of the additional market outlets. For example, community seed producers were linked to Alheri Seed Company in Niger, Premier Seed and Jirkur Seed Companies, as well as Grand Cereal Nigeria Limited Jos (Agro-processor) in Nigeria, and Leldet Seed Company in Kenya. Over the period 2008-2010, a total of 975 MT of soybean seed has been produced.

In Nigeria, 232.3 MT of Certified Seed has been produced in the last three years. This figure indicates that the 70 MT per year annual target was met.

In Kenya, 43 MT of Certified Seed has been produced. In Malawi, 122 MT of Certified Seed has been produced. In Mozambique, 578 MT of Certified Seed has been produced. The results indicate that Nigeria and Mozambique exceeded the target of 210 MT based on average of 70 MT per year. Over 90% of the seed produced has been certified by the country certifying agencies (Table 11-30).

Table 11-30: Quantity (MT) of Certified Seed of soybean produced in target countries

Country	Year			Total
	2008	2009	2010	
Kenya	10.0	13.0	20.0	43.0
Malawi	4.0	60.0	58.0	122.3
Mozambique	43.0	120.0	415.0	578.0
Nigeria	50.3	66.0	116.0	232.3

Total	**107.3**	**259.0**	**609.0**	**975.3**

Seed production was monitored throughout the project cycle. NARS kept careful records of initial Foundation/Certified Seed produced and distributed to partners, while selected partners in decentralized zones kept records of farmer multipliers, farmers receiving seed, and multiplication rates by region.

Seed delivery mechanisms

The use of small packs is based on the field insights that farmers want access to new varieties, and that some also are willing to pay for Certified Seed at affordable sizes. Seed simply has to be marketed in affordable sizes, in places which are easily accessible to farmers, and from vendors that farmers trust (or who may be held accountable to buyers). Available M+E data show that 3700 MT of seed has been sold in small packs across three countries. Of this amount, 226 MT was sold in Nigeria, 430 MT in Mozambique, and 44 MT in Kenya in small packs sealed in 2 kg, 5 kg and 10 kg sizes. At the beginning of TL II, NARS and NGOs considered that farmers only wanted large quantities, that is 50 kg and 20 kg packs.

Progress in on-farm demonstrations

Demonstration plots were established in all participating counties to popularize and showcase the performance of improved soybean varieties to large numbers of farmers.

In Nigeria, 365 farmers (259 men and 107 women) successfully established on-farm soybean demonstration plots in the project areas of Borno, Benue, and Kaduna States. The average yields for the improved varieties ranged from 1753 in the Sudan zone to 2149 kg per ha in the Savanna zone compared, to average yield of 1553 kg per ha of the farmers' variety. In 2010, 30 demonstration plots were established in Benue State. The average yield of the improved variety was 2181 kg per ha, compared to 1523 kg per ha of the farmers' localvarieties. In Mozambique, a total of 430 demonstration plots were established while in Kenya, 44 demonstrations were established.

Understanding and developing market-value chain

Soybean seed supply chain and other form of value-addition has been carried out in all project countries and reports submitted. Market development for soybean and linkages has resulted in increased production and sales of soybean making significant contributions to improving livelihood and poverty reduction.

Progress in market linkage

In Nigeria, two seed companies and a seed cooperative are involved in producing and selling soybean seed. These are Premier Seeds Nigeria Ltd, Project Seed Co. Nigeria Ltd and Jirkur Seed Cooperative; these entities have been linked to each other.

To ensure that seed producers have access to market outlet for the sales of their seed, seed farmers were linked to institutions that have the mandate for the crop and other major seed companies. The linkage was aimed to encourage the seed producers to improve and expand seed production as a result of the additional market outlets.

In Nigeria, a total of 226 MT of Certified Seeds of different soybean varieties have been sold in different packs sizes over the last 3 seasons. Of this total, 100 MT was sold in small packs of 1, 2 and 10 kg pack to farmers. In Mozambique, 430 MT of soybean varieties packaged in small packs were sold through input dealer shops and cooperative stores. In Kenya, a total of 44MT of different soybean seed has been sold over the last 3 seasons.

Progress in training farming communities

A number of training activities were carried out in the project countries with respect to seed production technologies, PVS, field plot techniques, seed segregation and standard, storage processing and utilization and marketing. In Nigeria a total of 567 farmers and 37 extension agents have been trained in seed production technology, and agronomic practices, segregation, standard, processing, storage and marketing.

A total of 230 farmers and 120 extension agents have been trained in Kenya on seed production technology and management practices of which 26% were women. In Mozambique, 482 farmers and 40 extension agents have been trained.

Lessons learned

TL II soybean seed systems Phase 1 lessons are listed below.

1. Building a strong effective partnership for widespread success: to deliver improved soybean varieties and production technologies require diverse partners in addition to the usual National Agricultural Research Institutions;

2. Complementary crop management technologies: Complementary crop management practices that contribute to increased yield promoted alongside improved crop varieties are two components to increase productivity;

3. A small pack marketing approach has the potential to reach hundreds of thousands of farmers, quickly. In both Nigeria and Niger, the sale of small packs has reached men and women farmers, and expanded the use of Certified Seed. It has also given farmers the opportunity to experiment new varieties at minimum risk. The small-pack model has already spread to other crops;

4. Monitoring and evaluation have been crucial for understanding project opportunity and constraints. Considerable energy was expended to develop and put in place for the Integrated Performance Monitoring and Evaluation (IPME) processes of the project and such start-up efforts should not be underestimated. IPME has also delivered quickly—especially in identifying some of the opportunities and weakness of the project;

5. Milestones achieved varied among countries due to limited human capacity and resources and commitment of partners; and

6. Four key factors, all concerning capacity building, played a significant role in TL II's success. These included the development of strong partnerships, sometimes now referred to as innovation platforms, the use of participatory approaches, the strengthening of community-based organizations, and the use of research knowledge. TL II promoted linkages and created a strong partnership between stakeholders. The project worked closely with State ADPs, providing training in PREA, as well as new agricultural technologies and management practices. This was undertaken in ways which reinforced each other based on the principles that people learn from practical experience and better from their peers.

Annex 11-1: Probit Model Estimate of Factors Affecting Farmers Adoption of Improved Soybean Varieties in Nigeria

	Participation in the TL11 (STATUS)	***Use of improved soybean varieties (Impvar)***	
Variables	Coefficients	Coefficients	Marginal effect (dy/dx)
Lage	-0.129* (0.070)	-2.043*** (0.621)	-0.138
Sex[a]	0.238* (0.146)	-0.911** (0.410)	-0.046
Educ2	-0.295** (0.140)		
Educ3[a]		-0.449 (0.414)	-0.038
Mstatus	0.132 (0.171)		
Fexp	-0.002 (0.006)		
Contact	0.398** (0.169)		
Infva[a]	-0.253 (0.161)	2.767*** (0.592)	0.468
SeedCollab	1.089*** (0.191)		
Contfreq3[a]		-1.022* (0.629)	-0.132
Soybexp		0.035** (0.017)	0.002
Vabuy[a]		-2.124*** (0.500)	-0.253
Inverse Mills ratio		-1.745*** (0.647)	-0.118
_cons		10.139*** (2.630)	
Number of observations	400	185	
Log likelihood	-237.23417	-41.187935	

([a]) dy/dx is for discrete change of dummy variable from 0 to 1
**=p<0.10; **=p<0.05; ***=p<0.01*

Annex 11-2: Tobit Model estimate of factors affecting farmers adoption of mproved soybean Varieties in project communities

Variables	Coef.	Std. Err.	P>t
Tsoyarea *(Dependent variable): Total land size cultivated for improved soybean varieties (ha.)*			
invmills1	-0.359***	0.093	0.000
Infva	0.029	0.070	0.681
Sex	0.077	0.071	0.278
educ1	0.070	0.109	0.523
educ2	0.035	0.099	0.726
educ3	0.336***	0.113	0.003
Soybexp	0.005*	0.003	0.080
Revenue	0.154**	0.066	0.021
Fields	0.058***	0.012	0.000
_cons	0.442***	0.161	0.006
/sigma	0.621	0.022	0.578
N = 395 Log likelihood = -374.078 Pseudo R2 = 0.112			
Obs. summary: 1 left-censored observation at tsoyarea <=.04 393 uncensored observations 1 right-censored observation at tsoyarea>=5.94			

*N= number of observations; ** significant at 5% (p<0.05) probability level; *** significant at 1% (p<0.01) probability level*

Note:

STATUS whether the farmer participated in TL 11 project improved soybean promotional activities. It takes the value 1 if the farmer ever participated and 0 otherwise. It is expected that farmers' participation in soybean promotional activities may have a greater influence on adoption decision. This variable may also be a source of endogeneity in the regression model.

AGE- This variable measures the age of the farmer in years. It is assumed that younger farmers can easily accept innovation than older. However, it is also assumed that adoption is positively related to age because older farmers have accumulated resources which they can plough back into the farming operation.

SEX- is the sex of the farmer that takes the value1 is the farmer is a male and 0 if female. The expected sign for this variable is ambiguous and may vary with the environment over which the technology is introduced.

EDUC-is defined as the education level of the respondent. This variable is split into four dummies including Educ0 for farmers who received no formal education, Educ1, Educ2, and Educ3 for those who attended primary, secondary, and post secondary school respectively. Educ0 was chosen as the basic group for the models. It is therefore hypnotized that the educational level of farmers in this study is positively related to adoption of improved Soybean varieties.

FEXP – is defined as farming experience which reflects the number of years of farming. This variable is therefore hypothesized to have a positive influence on farmer's adoption decision of improved Soybean varieties in the study area.

MSTATUS-measures the social or marital status of the respondents. It takes the value 1 if married and 0 otherwise. The effect of this variable cannot be determined *a priori*

REVENUE- measures whether the farmers has another source of income outside farming activities. It is assumed that off farm income can help household to have better access to production inputs such as improved seeds. It is also argued that farmers' engagement in off farm income generating activities will be less likely to invest in farming activities. The expected sign of this variable cannot be predicted.
SOYBEXP- is the numbers of years the farmer has been growing Soybean varieties. The more the farmer is experienced, the greater his willingness to adopt new technologies.

CONTACT- measures whether the farmer receives advices with extension services. It takes the value 1 if the farmer had contact with extension services, and O, otherwise, Because contact with extension to services allows farmers to have greater access to information on improved technologies and are provided with opportunity opportunities to participate in demonstration trials and other promotional activities,(whittome et.al.,1995, Dvorak,1996) it is hypothesized that CONTACT will positively influence farmers adoption decision of improved Soybean varieties in the survey communities.

FIELDS- is the number of fields owned by the farmers. Farmers with more fields are expected to accumulate more income that can used to finance farming activities especially improved technologies. It is hypothesized that FIELDS have a positive influence on farmer's adoption decision of improved Soybean varieties in the study communities.

INFVA-whether the farmers do get information on improved Soybean varieties. It takes the Value 1 if farmer has access to information on improved Soybean varieties and 0 if otherwise. It is assumed that farmers who get information on new technologies are often in better position to determine the benefits of that position to determine the benefits of that technology. IVFVA is therefore hypothesized to be positively related to farmer's adoption decision of improved Soybean varieties in the study area.

VABUY-whether a seeds market is available in the village. It takes on the value 1 if market is available and 0, if otherwise. This variable is hypothesized to influence positively adoption.

SEEDCOLLB- whether a farmer participate in community-based seed multiplication programs. It takes on the value 1 if he participates in seed multiplication programs and 0 otherwise. We assume that farmers who is involved in seed multiplication program is more likely to be selected for TLII improved soybean promotional activities and thus may have a high propensity to adopt the improved soybean varieties.

CONTFREQ- it indicates the frequency of farmer's contact with extension services. This variable is split into tree categories: CONTFREQ1, CONTFREQ2, and CONTFREQ3- when the frequency is less than once a month, once a month, and more than once a month respectively. Each category is considered as a dummy in the model. It is assumed that frequency of visits is positively related with adoption.

Tropical Legumes II Project

The Tropical Legumes II (TL II) project, funded by the Bill & Melinda Gates Foundation, aims to improve the lives and livelihoods of smallholder farmers in the drought-prone areas of Sub-Saharan Africa and South Asia through improved productivity and production of six major tropical legumes – chickpea, common bean, cowpea, groundnut, pigeonpea and soybean. TL II is jointly implemented by ICRISAT, CIAT and NARS. The project was implemented in 10 target countries that included Western and Central Africa, Eastern and Southern Africa and India, during Phase 1 (Sept 2007 – Aug 2011). Progress made during this period was reviewed in 2011 at regional meetings held in ICRISAT-Patancheru, India (May 9-11 and Sept 5-6), Ibadan, Nigeria (16-18 May); and Lilongwe, Malawi (22-25 May). This report presents highlights of progress made in the project during its first phase.

Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture
A Remarkable Record of Science for Change
Since 1967

ISBN: 978-92-9066-546-5 Order Code: BOE 057

Research to Nourish Africa